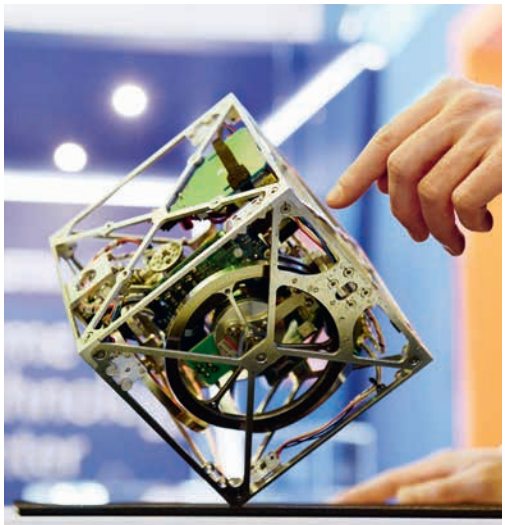
ETH DOMAIN

2017

ANNUAL REPORT

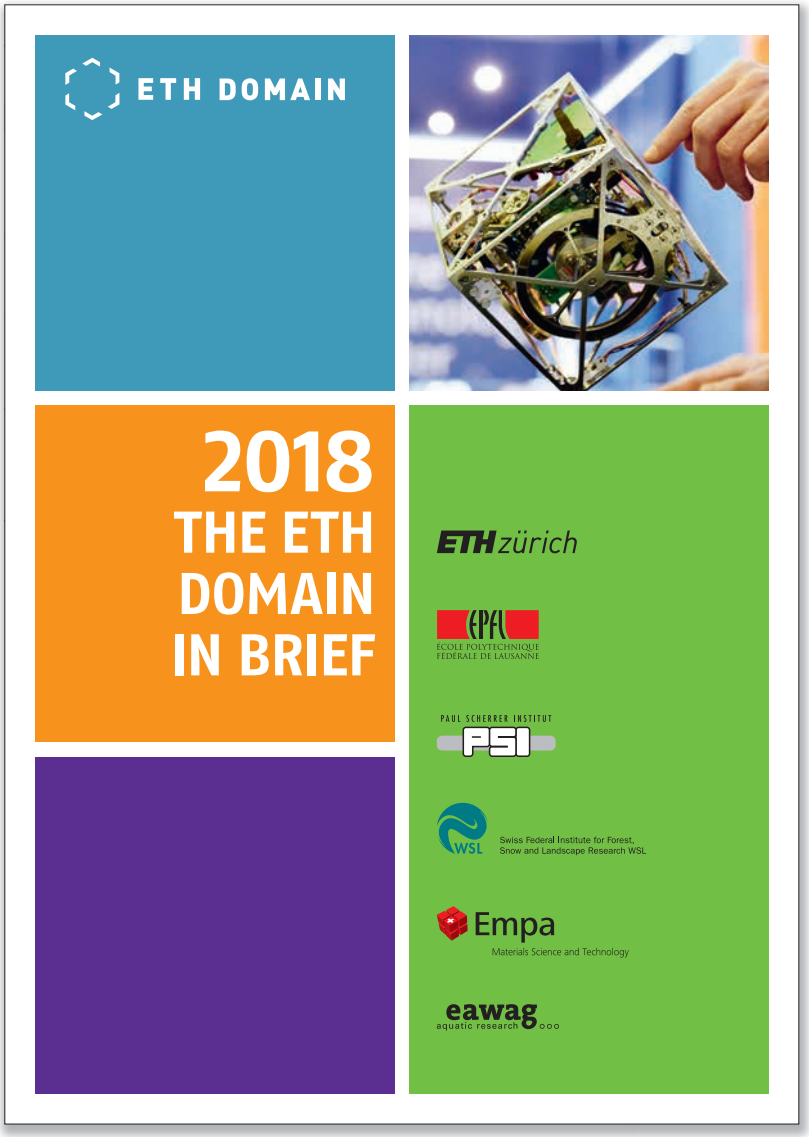
of the ETH Board on the ETH Domain



Mission Statement

The ETH Domain strives to strengthen the competitiveness of Switzerland in the long term and contribute 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.

ETH Domain in brief



Contents

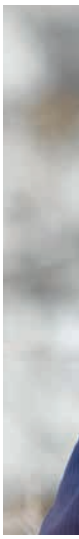
2,530.8 m
Total federal contribution

743 m
Research contributions, mandates and scientific services

21,490
Employees*

474
thereof apprentices*

34%
share of women of total staff of the ETH Domain



31,293
Students and doctoral students

850
Professors *

206
Patent applications

297
Licences

48
Spin-off foundations

29.5%
of professorships awarded to women

ETH Zurich

Ranked 4th	in THE Europe Ranking
Ranked 10th	in THE World Ranking
Ranked 10th	in the QS World Ranking
Ranked 5th	in the QS Europe Ranking

EPFL

Ranked 1st	in THE "Young University" Ranking
Ranked 10th	in THE Europe Ranking
Ranked 12th	in the QS World Ranking
Ranked 6th	in the QS Europe Ranking

* Employment contracts

Dear Readers

31,293 – that's how many students and doctoral students there were enrolled at the two Federal Institutes of Technology in 2017. That is 1,000 up on last year, and 10,000 more than there had been ten years ago. An ever increasing number of the next generation of Swiss professionals are pursuing their studies within the ETH Domain. And that can only be a good thing. Our industry, SME sector and authorities are reliant on recruiting employees who have received an excellent education. Whether it be in construction, information technology, agriculture, pharmaceuticals or in the mechanical engineering industry. The ETH Domain educates these much needed specialists. It is actually the only university-level education institution in Switzerland in certain disciplines, such as mechanical and electrical engineering. Year in, year out over 4,000 people complete their Master's degree or their doctorate at one of the two Federal Institutes of Technology and go onto the Swiss labour market or, as is increasingly the case, set up their own company. The four research institutes of the ETH Domain are also very committed to teaching. 2017 saw record numbers of students and doctoral students complete their dissertations and theses at the PSI, WSL, Empa or Eawag.

What's more, an additional 10,000 students and doctoral students require additional laboratories and lecture halls, as well as professors and technical personnel. This growth in student figures would not be manageable without additional investment. The ETH Domain is very successful in seeking funding from private benefactors, the Swiss National Science Foundation, Innosuisse and the EU. However, the funding from the total federal contribution is still by far the most important source of financing.

Education is worth investing in. A current study now reveals specific figures for the ETH Domain. In 2016, the ETH Domain had a gross value added effect of around 13 billion francs in Switzerland, accounting for almost 100,000 jobs. This means that every franc invested in the ETH Domain generates more than five times its value, and every job generates around four further jobs. Its institutions attract foreign companies and create employment themselves with the founding of spin-offs. The ETH Domain is an important player in our economy and a key ambassador abroad for our outstanding education and research centre, as well as for nurturing the good reputation that Switzerland enjoys generally. Thanks to its research findings and to its close collaboration with industry, it makes a vital contribution towards the competitiveness of and quality of life in Switzerland.

Zurich / Bern, February 2018

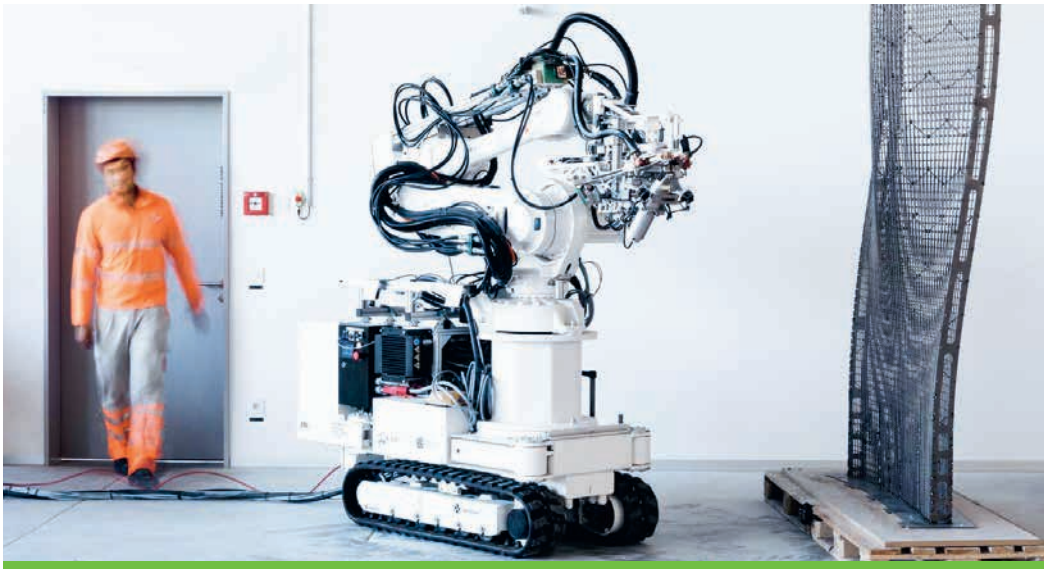
Dr Fritz Schiesser *President of the ETH Board*

Highlights 2017

WSL

WSL at the WEF in talks with politicians

WSL co-organised and hosted the high-quality "Arctic Basecamp" event at its Davos site during the World Economic Forum (WEF). Polar researchers, business delegates and politicians from Switzerland and abroad shared views on what impact climate change in Arctic regions will have on the global economy. Leading contributors such as former Executive Secretary of the UN Framework Convention on Climate Change Christiana Figueres, former US Vice-President Al Gore and WSL Director Konrad Steffen took advantage of the presence of the WEF participants to share scientific findings with wider society and to promote fact-based dialogue.
Photo: Phil Wenger/WSL



ETH Zurich

Digitally designed, planned and built

The NEST building, which is home to Empa and Eawag in Dübendorf, is set to be the site of the world's first house which is not only digitally designed and planned, but which will also be built largely with digital processes, robots and 3D printing. Eight professorships from various scientific disciplines at ETH Zurich are testing innovative construction methods from the laboratory under real conditions for the first time at the three-storey DFAB HOUSE. They are seeking to investigate the extent to which these digital technologies can make building more sustainable and more efficient and also increase design potential. The project was created with the participation of business partners within the scope of the National Centre of Competence in Research Digital Fabrication.
Photo: ETH Zurich/Empa

EPFL

Victory in the Solar Decathlon

Switzerland was the clear winner on its first attempt at the Solar Decathlon with a partnership between EPFL, the Fribourg School of Architecture and Engineering and the Geneva Haute école d'art et de design. This Solar Decathlon was staged by the US Department of Energy and pitted universities from all around the world against one another. The objective was to plan and build an innovative house that meets its entire energy needs through self-generated solar power. The Swiss team of 250 students, three-quarters of whom are from EPFL, spent three years working on this project. 43 students travelled to Denver to defend the project. The upshot was that the Swiss Team secured podium finishes in eight of the ten disciplines, coming out on top in six of them. *Photo: Fred Hatt/EPFL*

Empa

Advanced Manufacturing gathers pace

The manufacturing industry is currently experiencing a revolution. Completely new of networking computers, data and physical objects are springing up, changing our manufacturing practices. "Advanced Manufacturing", a newly established strategic focus area in the ETH Domain, headed by Empa, is aiming to help to make targeted use of the potential of digitisation and innovative production methods for Swiss industry. At the official opening on 13 November in Bern, Federal Councillor Johann Schneider-Ammann praised the strong standing of Swiss research institutions in the wider world in this area, but stressed the need to keep an eye on changes in industry.

Photo: Empa

www.sfa-am.ch

PSI

Non-destructive look at computer chips

The power lines and transistors of the electronic chips in modern computers and mobile phones are only a few nanometers in size. While the production of these structures is standardised, the measurement of the finished chips remains time-comsuming. Researchers at the PSI have successfully taken 3D X-rays of the inner workings of a standard commercial computer chip for the first time. In experiments using the Synchotron Light Source (SLS), it was possible to carry out non-destructive imaging of the tiny structures. The objectives of the development work are ambitious and reflect the interests of the semiconductor industry; while the area examined up to now is only a few micrometers in size, entire microchips will be able to be examined non-destructively within an acceptable measuring time in future.

Eawag

Agriculture which is less harmful to water

Agricultural practices which are both productive and less harmful to water remain a challenge. Pesticides are frequently found in rivers, streams or lakes. This has led to political initiatives, such as the development of the "National Action Plan on Pesticides", which the Swiss Government hopes will halve risks and encourage alternatives to chemical plant protection. This year's Info Day at Eawag in September 2017 demonstrated that the conflicts that exist between agricultural use and the protection of water can be addressed with objective dialogue, transparent targets and a raft of measures.

Finances

Financing and annual financial statement

The ETH Domain is primarily (86%) financed by way of direct financial contributions (total federal contribution; 71%) and indirect contributions (15%) made available by the Swiss Confederation. There is a budgetary framework of a maximum of CHF 10,337.8m available for the 2017–2020 ERI period. The credits of CHF 2,530.8m in 2017 exceeded the previous year's figure. As a result, the ETH Domain is likely to have a total of CHF 10,148.2m at its disposal for the 2017–2020 ERI period. The credits imputed to the budgetary framework cover the financial requirements for the basic facilities for teaching and research, and the share of construction investments for the state-owned property used by the ETH Domain. In addition to the total direct federal contribution, the Swiss Confederation indirectly covers a further 15% of the financing of the ETH Domain via competitive research contributions.

The annual financial statements of the ETH Domain comprise the statement of financial performance, balance sheet, cash flow statement, statement of changes in equity and notes. They are prepared based on the International Public Sector Accounting Standards (IPSAS) and in accordance with the requirements of the Ordinance on Finance and Accounting of the ETH Domain. The institutions of the ETH Domain are among the world's first universities and research institutes whose annual financial statements have been prepared and certified in accordance with IPSAS.

The 2017 accounts closed with a surplus of CHF 209m, which equates to a drop of CHF 80m (28%). The decrease is mainly a consequence of the 6% rise in operating expenses, compared to lower growth in operating revenue of almost 3%. The annual surplus or deficit must be determined from the operating result, net finance income/expense, as well as from the result from associated units.

Total assets rose at the end of 2017 from CHF 5,041m to CHF 5,837m, due in particular to the rise in property, plant and equipment, and – due to this being reported for the first time – investements held in associated entities, as well as receivables. In the latter case, there was also a strong shift in non-current assets and an increase in current assets overall. A huge shift occurred within liabilities and equity resulting from the drop in net defined benefit liabilities in liabilities and the corresponding rise in equity. The effects of the actuarial insurance assumptions, which had changed compared to the previous year, led to this positive change in the valuation reserves in equity.

CHF 209m
Surplus

Making huge reductions in energy consumption and producing the remaining energy internally. That is also the concept promoted by the "Solar Fitness & Wellness" in the NEST. *(Photo: Empa)*

Fig. 1: The main financial indicators 2015–2017

CHF millions	2015	2016	2017
Statement of financial performance			
Operating revenue	3,475	3,598	3,698
Operating expenses	3,252	3,314	3,515
of which personnel expenses	63.0%	63.4%	65.5%
Surplus (+) or deficit (–)	214	289	209
Balance sheet			
Current assets	1,994	2,149	2,771
Non-current assets	2,693	2,892	3,066
Total assets	**4,686**	**5,041**	**5,837**
Liabilities	4,321	4,918	4,625
Equity	365	123	1,212
Equity ratio	8%	2%	21%

CHF 5,837m
Total assets

As a consequence, equity increased by around CHF 608m, and the net defined benefit liabilities in liabilities was down (CHF –678m). A further effect that impacted upon the level of equity arises as a result of entities that are controlled or significantly influenced by institutions of the ETH Domain being considered in the consolidated financial statement for the first time. Following the implementation of the transitional provisions of the Ordinance on Finance and Accounting of the ETH Domain, the sub-consolidated financial statements – particularly those relating to the two Federal Institutes of Technology – contain the values, including those relating to controlled and associated entities, in the assets and liabilities. This led to an increase in total assets of the ETH Domain by a total of a further CHF 148m in equity. The rise in free and dedicated reserves completes the growth in equity by a total of CHF 1.1bn compared to 2016.

Conclusion: The most important changes in the 2017 annual financial statements, both in the statement of financial performance and in the balance sheet, are associated primarily with IPSAS 39 procedures (net pension costs and net defined benefit liabilities). Another important effect reflected in the numbers comes from the inclusion of investments held for controlled and associated entities.

Personnel

Continued moderate growth

In 2017, a total of 21,490 employees* (2016: 21,054) worked for the institutions of the ETH Domain. At the end of 2017, the personnel in the ETH Domain amounted to 18,631.6 full-time equivalents (FTEs) (2016: 18,255.9 FTEs). While the rise was a little higher than in 2016, it was in the lower range of previous growth rates. However, at the end of 2017, the proportion of women in the ETH Domain broke through the 34% mark for the first time. And the figure for women with professor status also rose from 13.9% to 14.9%. Women accounted for 29.5% of all appointments, up on the previous year (24.1%). The ETH Domain is seeking to raise the number of women in teaching and science, as well as in leadership positions. For this purpose, the ETH Board implemented a Gender Strategy for the 2017–2020 period (see p. 102) in the year under review. The number of apprentices rose to 474 at the end of 2017 (2016: 464).

* Employment contracts

CHF 120m
for renewable energy

Real estate

Challenges in the real estate sector

Real estate management in the ETH Domain faced substantial challenges in 2017. The ongoing increase in students was accompanied by an increase in the number of professors. This trend looks set to continue and will lead to an increased need to expand and adapt the premises and technical infrastructure. The funds for ETH Domain constructions for the period 2019–2021 were affected by an austerity programme as well as a programme to increase efficiency by the Federal Council. This meant that the investment planning had to be adapted, which had an effect on projects already planned or ongoing in the year under review. The cuts can be partially absorbed by the delays in construction projects already commenced. The challenge facing the ETH Domain is to meet the high targets set by the Swiss Confederation to lead by example in energy and sustainability, to ensure the preservation of value and functionality, as well as to provide the right framework conditions at the right time for teaching and research.

Energy and environment

Promotion of renewable energy

The ETH Domain was part of the Federal Government's management of resources and the environment programme (RUMBA) from 2006 to 2016. The final report was published in September 2017. RUMBA was permanently assigned to the Federal Administration by the Federal Council in 2017. However, the comparability of the reports made by the ETH Domain (see fig. 32, p. 114) and the RUMBA figures will continue to be guaranteed. The annual report for 2016 entitled "The Confederation: exemplary in energy" published by the Swiss Federal Office of Energy (SFOE) in 2017 contains further details about the energy commitment shown by the institutions. At the end of 2017, the institutions submitted an action plan to the Federal Council for the production of renewable energy for their own needs with investment costs of approximately CHF 120m by 2024.

The ETH Domain – a driving force in digitisation

Digitisation will lead to far-reaching changes to the economy, society and science in the years ahead. It represents a great opportunity for Switzerland. The necessary preconditions have to be created to make successful use of this. The institutions of the ETH Domain will play a key role in this.

The Swiss Federal Council explored the theme of digitisation in the economy, research and education in just three extensive reports in 2017, finalising the strategy for "Digital Switzerland" that it had adopted the year before. On the one hand, it focused its attention on the impact of digitisation on employment and work conditions and, on the other hand, on the central framework conditions for a digital economy in Switzerland. A third report on "Challenges of Digitisation for Education and Research in Switzerland", which was published in July 2017, also commented upon the fundamental part to be played by education and research.

Eight action fields are defined in this report with which Switzerland will seek to tackle the challenges of digitisation in education and research. Two of those action fields assign a key role to the ETH Domain: Additional professorships are intended to underpin basic research in the fields of IT and/or computer science in the ETH Domain. According to the Swiss Federal Council, it will serve to "safeguard an institutional basis which will enable the two Federal Institutes of Technology to keep pace with the resources available at the world's leading reference centres". In particular, it should serve to consolidate the leading positions occupied by ETH Zurich and EPFL in fundamental research in the technical disciplines which are pivotal to the design of digitisation. The institutions of the ETH Domain have made an undertaking to abide by this mandate in their own strategic positioning. The Federal government's action plan will additionally aid those activities.

A nationwide network of Advanced Manufacturing Technology Transfer Centers is to be developed as one of the measures of the action plan to "Promote innovation: Accelerate knowledge transfer". Industrial enterprises and, in particular, SME are especially confronted by the challenges posed by digitisation in the field of advanced manufacturing technology. According to the Swiss Federal Council, the development of manufacturing technology like this would require intensive inter- and trans disciplinary collaboration between different fields and increased cooperation between science and industry. The ETH Domain is to assume a leading role in that.

The ETH Domain has specified the development of a strategic focus area for advanced manufacturing for the strategy period from 2017–2020, which is similar in its positioning but covers more extensive topics, underpinning the objective of the Swiss Federal Council, as well as its efforts and role in this field. It is essential that the requisite resources – as they were in the past – are available for the resulting tasks and orders. The institutions of the ETH Domain are dependent on being promised suitable resources for tasks which have been prioritised politically. This is essential to enable the ETH Domain to meet the justifiably high expectations.

Digitisation and security

The issue of the risks and security arising within the virtual environment, i. e. dealing with cyber risks and cyber security, has gained in attention and significance in the context of digitisation. With an increasing number of incidents in companies and at state agencies, the Federal Parliament has tackled the issue with a number of initiatives.

Cyber security: the ETH Domain is playing a central role in this

Reference has also been made to the growing significance of research and enhanced competence for dealing with cyber risks and cyber security. Here, too, the institutions of the ETH Domain are central figures and partners for public agencies which are responsible for cyber security. This also applies to collaboration with private sector organisations. For instance, the Center for Security Studies, which was founded in 1994, and the Zurich Information Security & Privacy Center (ZISC), which was founded in 2003; they are involved in teaching and research in these fields at ETH Zurich. In the latter, there are four professorships in the core area and twelve associated professorships with their research

groups working closely in an Open Lab with various industrial partners, including IBM, Google, ZKB, SIX, Crédit Suisse, Zurich Versicherungen, Die Post, armasuisse open systems and NEC. The Security and Cryptography Laboratory (LASEC), among others, does this at EPFL. Last but not least, cyber security is also a key focus activity at EPFL Innovation Park Lausanne. In this regard, EPFL is planning a Center for Digital Trust in association with industrial partners.

The institutions of the ETH Domain have laid great store by teaching and training in the area of cyber security for years. With that in mind, they take whatever steps are necessary to consolidate or expand their role as global leaders.

Digitisation – also an issue for the four strategic focus areas

Strategic focus areas successfully launched

The four strategic focus areas defined by the ETH Board in its Strategic Planning for 2017–2020 are concerned with the important challenges of digitisation. All four work with large data records or high resolution digital images and measurement series from complex processes in the environment, in machines and in buildings, which undergo computer-aided analysis or simulation.

Photo: Paulus Rusyanto/shutterstock

Energy
The focus on "Energy" will build on the activities that were previously developed in the "Coordinated Energy Research Switzerland" action plan from 2013–2016. These activities are not only geared towards issues of energy efficiency, renewable energy, impact research or the use of chemical processes for energy generation and storage, but also the integration of the individual systems which requires a high degree of digitisation. For that purpose, specialist research platforms, such as the "Energy System Integration Platform" (ESI), were set up on the PSI site (see p. 22 f.) or Empa's research platform ehub (s. p. 53). Energy research was financed with additional funds totalling CHF 60m in the 2014–2016 period and will now be continued from the funds of the basic budgets of the institutions.

Personalized Health and Related Technologies
The "Personalised Health and Related Technologies" (PHRT) strategic focus area is seeking to link the growing body of available health-related data to more targeted patient care. The health of the public could also benefit from more targeted preventative measures. Close collaboration between natural and engineering sciences and medicine is vital for this, which accounts for the close interaction with the Swiss Personalised Health Network (SPHN). Four key themes were set by the management bodies of the focus area:

- First of all, technology platforms are to be set up to process large volumes of personalised patient and clinical cohort data. The data generated must meet common standards so that it can aid clinical decision-making directly.
- Secondly, a technology programme is being developed in order to advance innovative clinical application technologies pioneered by the ETH Domain.
- Thirdly, the focus area supports personalised health research projects which are directly relevant to patients. Some of these projects are carried out and financed jointly with the SPHN.
- Fourthly, a programme for doctoral students and postdocs is to be developed in the field of personalised health within the scope of the focus area.

The first project call attracted a great deal of forward-looking research projects, which demonstrates the great interest there is in these key themes. There is a total of CHF 50m available for the PHRT focus area from 2017–2020.

Data Science
The "Data Science" focus area, which will benefit from a total spend of CHF 30m from 2017–2020, is central to digitisation. Data science contributes towards a better understanding and towards the targeted use of huge volumes of data for scientific purposes, but also towards the secure handling of this data. Among other things, research and teaching in the field of data science benefit many of the fields of research where scientists from the ETH Domain work. That prompted EPFL and ETH Zurich to build the Swiss Data Science Center (SDSC), which brings together data scientists and researchers from the various areas of application. The SDSC supplements and uses existing research infrastructure, such as ETH Zurich's Swiss National Supercomputing Centre (CSCS) and provides researchers with specific support in the area of data science. This twin focus, i. e. both research in data science and in researcher services, is also reflected in the project calls launched in 2017. They served to finance specific data science projects and the use of data science competencies in research projects comprising different disciplines. ETH Zurich and EPFL also developed a Master's degree in Data Science, which was successfully launched in autumn 2017.

Advanced Manufacturing
Through its strategic focus on advanced manufacturing, the ETH Board has reaffirmed the ETH Domain's central role in the area of advanced manufacturing technologies. Its key relevance in the context of digitisation is underlined by the focus placed on this by the Swiss Federal Council (see p. 8). The focus area was originally allocated CHF 10m by the ETH Board within its strategic planning for 2017–2020. However, given the sharp growth in its importance and the great interest in it, it decided to double the amount set aside for this to CHF 20m in 2017. Following its successful establishment, the advanced manufacturing focus area has been unveiled to the wider public, and lively exchanges with key players from industry have been an important aspect of this, in particular. The three original focus areas, namely high-precision free-form production of small parts, printable electronics, and sustainable use of digital production processes, now support seven projects that all have great potential for practical applications, with an emphasis on industrial usability.

Plotting a course in teaching

Numerous teaching initiatives have been implemented and stepped up in addition to the new Master's degree programmes mentioned above at ETH Zurich and at EPFL, serving to promote the use of digital technology in the classroom. This applies both to on-site services, as well as to online offers such as the established MOOCs (Massive Open Online Courses). The Extension School has been developed at EPFL with the aim of making increased use of the many possible applications of online courses. In addition, participants receive a certificate confirming that they have successfully completed a course (see p. 43).

Over 31,000 students and doctoral students

The repeated rises in figures among students (25,059) and doctoral students (6,234) are proof that the courses at the two Federal Institutes of Technology continue to be extremely attractive. The ETH Board attaches absolute priority to quality assurance and to safeguarding the associated attractiveness of the courses at the two institutes. These efforts were one of the reasons that prompted it to adopt a policy in 2017 in favour of raising tuition fees. The plan is to stagger the rise in tuition fees at both Federal Institutes of Technology by a total of CHF 500 to CHF 1,660 in future, starting from the 2019/2020 academic year. The explicit objective is to invest the additional resources in the quality of teaching and to cushion the impact for those students who would find it difficult to study because of the increased costs. Following an internal hearing at the ETH Domain and an intra-departmental consultation, a definitive decision will be taken by the ETH Board in spring 2018.

At present, the courses at the institutes, which lead to very high level qualifications but which are very costly, are among the most favourable university courses in Switzerland. In the past 10 years alone, student numbers at both Federal Institutes of Technology have risen by around 55%, markedly outstripping the funding promised to the ETH Domain by the Swiss Confederation. Therefore, this welcome rise presents the two universities with major challenges. In order to guarantee a good supervision ratio and the requisite infrastructure, additional funding is essential for the ETH Domain under these circumstances.

Successful launch of Human Medicine

The Bachelor's degree course in Human Medicine at ETH Zurich got off to a successful start in autumn 2017. There were a huge number of prospective candidates for the 100 places on the course. In addition to medical aspects, the course also includes in-depth content from the field of technology and natural science. The expansion of links with universities in western Switzerland is under way. Thanks to what is known as the passerelle, selected students from EPFL can go on to study Medicine at the universities of Lausanne (existing) and Geneva (new) once they complete their Bachelor's degree. The increase in the number of places provided in the Federal Government's special programme for Human Medicine was implemented right from 2017.

Finally, Switzerland's renewed full association with the EU Framework Programmes for Research and Innovation Horizon 2020 has also had a positive impact. This is borne out by the prestigious ERC grants, which have once again been received in large numbers (see also p. 98 f.).

Fascination ETH Domain

ETH Zurich

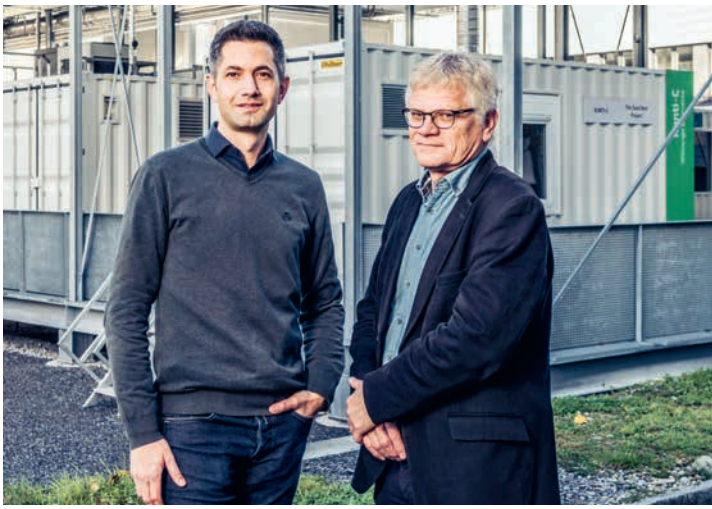
Innovative impetus for skin research

Skin is the subject of a major project called SKINTEGRITY, involving a collaboration between ETH Zurich, the University of Zurich and university hospitals. Co-leader, cell biologist Sabine Werner is working with engineers to investigate the molecular mechanisms of wound healing and the parallels with the development of cancer. → *p.* 18

ETH Domain

Designing the networked future

Digitisation is spreading throughout our daily lives and is changing the world. The ETH Domain's objective is to advance the development to best benefit the Swiss economy and society – from efficient environmental monitoring to new manufacturing technology, and from an improved Internet to the protection of medical data. *(Photo: Murielle Gerber/EPFL)* → *p.* 14



WSL

Genetics for conservation

How can genetic information be used to plan green bridges over motorways more effectively or to prove the presence of a rare species of newt in a pond without any sightings of the animal? Researchers at WSL are using genetics as an effective conservation tool, making the new techniques practical for users. → *p.* 24

Eawag

Heating and cooling with lake water

Lakes and large rivers have huge heat potential which can be tapped into without posing any harm to the environment. This is demonstrated by studies conducted at Eawag. The water research institute of the ETH Domain advises authorities on using energy as cleanly and as sustainably as possible. → *p.* 28

PSI

Storing power in gas

"Power-to-gas" is the name of the concept aimed at connecting the power network to the natural gas network. Researchers at the Paul Scherrer Institute hope that it will enable solar and wind energy to be stored longer. Collaborating with industrial partners, they are testing procedures under real conditions on a platform with containers packed full of high-tech equipment. → *p.* 22

EPFL

Virtual time machine

At EPFL researchers are working together with colleagues from Italy on the construction of a time machine that will allow you to immerse yourself in the Venice of the past. The team, headed by Frédéric Kaplan, has already digitised two million documents and images for this purpose. Specially developed search engines are bringing this digital heritage to life. → *p.* 20

Empa

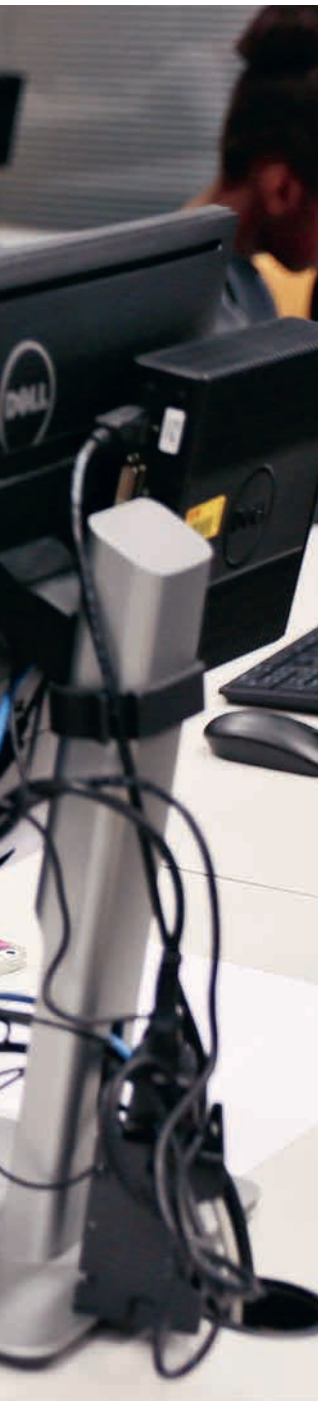
When your back hurts

Researchers at the Empa are investigating the biomechanical causes of pain in the lumbar region. The forces which put a strain on the back can be identified by combining computer simulations with 3D X-ray videos. The objective is to plan operations more effectively and to develop new implants. → *p.* 26

Digital Day 2017 on the EPFL campus: 13–15 year old girls who have already completed the EPFL courses "Internet & Code for Girls" and "Robots are indeed for girls" programme smartphone applications in a workshop.
(Photo: Murielle Gerber/EPFL)

Designing the networked future

Digitisation is spreading throughout our daily lives and is changing the world. The ETH Domain's objective is to advance the development to best benefit the Swiss economy and society – from efficient environmental monitoring to new manufacturing technology, and from an improved Internet to the protection of medical data.



Crossing the street in Fehraltorf, you would never know that there is a constant stream of data being recorded and transmitted up from beneath your feet. The water level in the drainage canals, which run under three quarters of all the city's streets, is detected by sensors in that district of the canton of Zurich. The ultrasound level sensors under the manhole covers transmit the measured values wirelessly to a base station at five-minute intervals; the base station, in turn, forwards the data to an Internet server.

The sensors in the sewage system are part of a unique field experiment led by environmental engineer, Frank Blumensaat at Eawag. "Digitisation creates previously untold possibilities," explains the urban water management specialist, who is also a lecturer at ETH Zurich. "Data can increasingly be recorded and transmitted in a resource-efficient manner using geographically distributed sensors." An innovative aspect of the work in Fehraltorf is the combination of robust and energy-efficient sensors and data transmission from underground via low-power wireless technology or LPWAN, which is short for the Low Power Wide Area Network of the Internet of Things (IoT). The Eawag researchers are seeking to capture the district water regime with a hitherto unknown degree of accuracy.

Their aim is to find out more information about drainage in areas that are not readily accessible and to use these findings in a meaningful way, for instance to give early warnings of floods in the event of heavy rain or of contamination. The network of sensors can also be used to find out how much sewage is discharged into streams, rivers and lakes and how this pollution can be minimised. The project will also provide training for students who, as the engineers of tomorrow, will bring that new expertise into planning offices.

"We have had good feedback from users"

Digitisation has also long since been used in forestry, more recently in tackling the bark beetle. If the forest ranger wishes to know what the situation is with pests in his area, he can go to the website of the Swiss Federal Institute for Forest, Snow and Landscape Research WSL to call up information about current developments with the bark beetle. "The information is based on a computer simulation for all of Switzerland," explains Beat Wermelinger, Head of the Forest Entomology Research Group at WSL. The daily temperature data is supplied by MeteoSchweiz for a high resolution 2×2 kilometre grid.

"Temperature is the most important factor in insect development," explains the specialist. Based on the temperature totals, researchers can determine when hatching will end in the bark of the spruce trees and the beetles will emerge. "Our model shows the daily development status of a population depending on altitude and exposure and how the emergence of the beetles is spread over time." In order to tackle the problem, trees affected have to be felled while the insects are still in the trunks because a single spruce can be home to up to 50,000 beetles. "Traps that catch a few thousand of the insects are not much help," explains the expert.

However, he does stress that the bark beetles play an ecological role; as pioneer settlers, they return freshly dead trees to the resource cycle. That said, with dry periods becoming more frequent due to climate change and there being a possible rise in serious storms, the bark beetles are able to settle in so many living trees in a weakened state that the insects have to be tackled. WSL has a website to provide assistance on this issue: www.borkenkaefer.ch. "We have had good feedback from users," says Wermelinger.

"Networking is the new thing"

Digitisation is making environmental monitoring more efficient and ensuring that, the economy will be in robust shape for the future. "Our production processes have to get in shape for industry 4.0," says Pierangelo Gröning, member of the Directorate of Empa. One type of production technology excellently suited to this is 3-D printing. Controlled by computer, this booming process enables bespoke single pieces to be manufactured without any human intervention in the manufacturing process. In this so-called additive production process, there are wider design possibilities than in conventional processes, and the design can be adapted optimally to the function of the piece.

It poses a special challenge to materials scientists. "In 3-D printing, you not only manufacture a product, you also synthesise the material from which the part is made at the same time," explains Gröning, who is coordinating the research on the topic of advanced manufacturing. Materials researchers at Empa are developing special metal alloys which are ideal for 3-D printing. It is worth noting, that the liquid material cools in fractions of seconds, whereas this takes much longer with the conventional casting process. "The new processes enable us to manufacture materials which would otherwise be impossible to melt metallurgically," explains the expert. "This represents a type of renaissance in industrial production for material science."

As the end product cannot be tested as it is a unique item, it requires a new system of quality management – process technology that, together with the product, delivers a data record which confirms that the piece conforms to specifications. "This is an opportunity for countries where quality is of the essence, as in Switzerland," says the materials scientist. However, the new production processes are complicated and require many process steps. Sensors deliver huge volumes of data which the computer has to process in real time in order to facilitate immediate intervention. For this purpose, everything must be networked. "Increasing networking is the new thing," says Gröning. Digitisation as such has existed since back in the 1960s.

"The mountain of data is growing massively"

"Digitisation is probably more advanced here with us than it is in most Swiss companies," explains Gabriel Aeppli, Head of the Synchrotron Radiation and Nanotechnology Research Division at the Paul Scherrer Institute (PSI). An ever-increasing volume of data is generated during the experiments on the large-scale research facilities. Aeppli explains that "in the time that it takes us to collect terabytes at present, we will be able to collect petabytes, i. e. a thousand times more, with the machines of the future." He anticipates that by 2022 the PSI will be gathering as much data in one day as the CERN particle research centre currently gathers in a whole year. "The mountain of data is growing massively," explains the physicist.

Current technology does not allow this information to be made accessible within a useful period of time. In order to compress, process and save the data, the specialists at the PSI have to develop new hardware and software platforms. The solutions which are being developed at the PSI will also be made available to Swiss industry. Digitisation repeatedly leads to spin-off companies, such as Dectris which develops pixel detectors which produce large volumes of data, or leadXpro which is looking for new active ingredient molecules for drugs – an undertaking based on particularly intensive data processing.

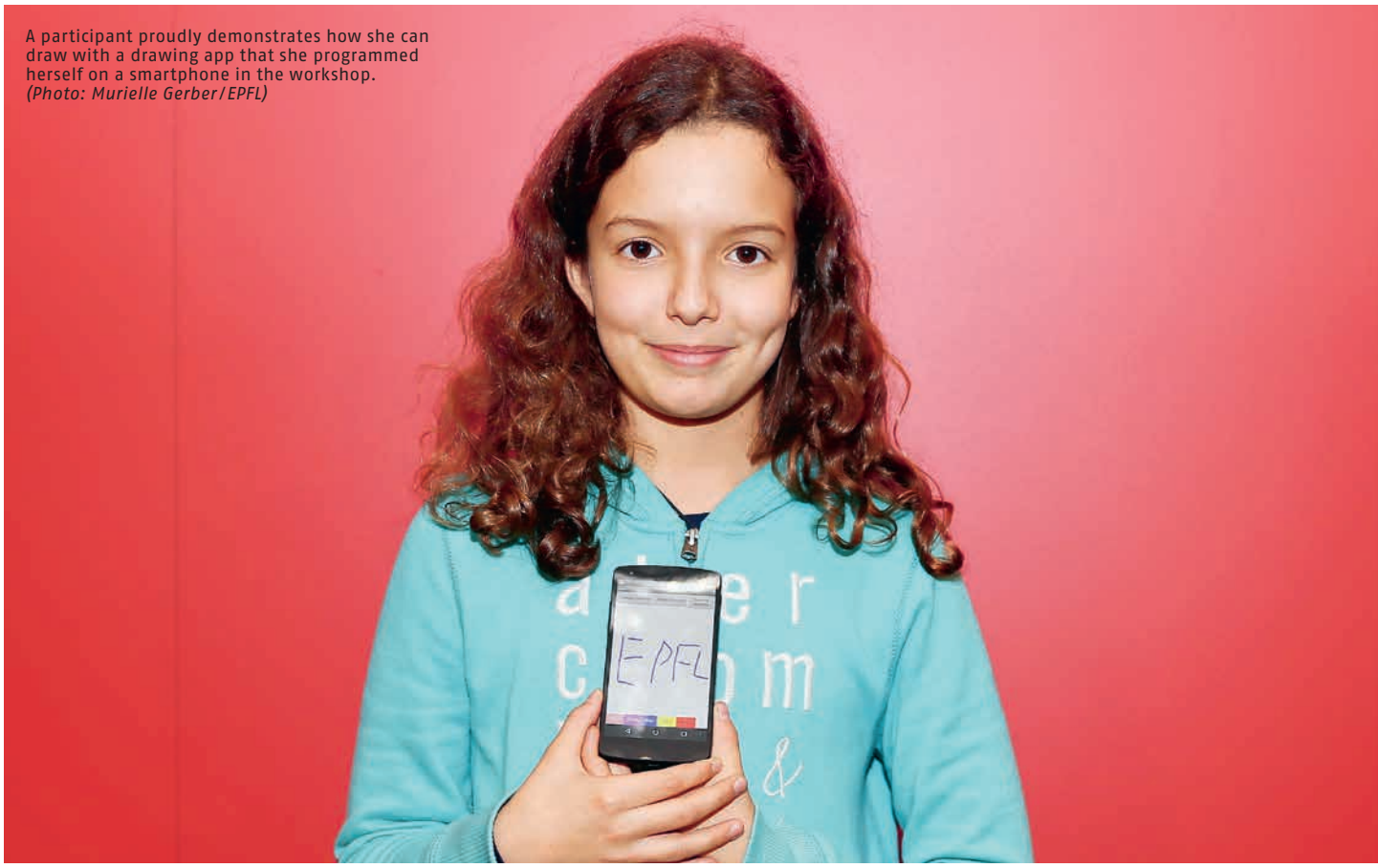
Aeppli also feels that the "Internet of Things" offers Switzerland a great opportunity. "We intend to incorporate Industry 4.0 in the forthcoming refurbishment of the Swiss Light Source," explains the Head of the large-scale research facility. The individual components will no longer be wired by hand, but rather via Wi-Fi. Industry also stands to benefit from the experience of the engineers at the PSI. "The same problems will still have to be solved in a factory; it is just that our systems will be rather more complicated," he explains. "We have the people who can design, organise and operate these systems. Consequently, the ETH Domain not only offers academic excellence, it also offers practical know-how."

"Tailor-made Internet"

Our present-day Internet connects billions of devices around the world which are exposed to immense risks; attacks are lurking from all sides because the technologies used no longer meet the requirements of an increasingly networked world. It is only a matter of time until the Internet collapses in its present form, until critical infrastructures become uncontrollable, until personal data gets into the wrong hands on a major scale, and until we finally wish we had an Internet tailor-made for the 21st century. Is there such thing as a really secure Internet? The SCION Internet architecture developed at ETH Zurich is the first completely redesigned architecture for the worldwide networking of devices that can easily withstand today's overload attacks (DDoS) and also meet all requirements of the IoT regarding security and availability of communication.

A number of companies are already testing SCION, including Swisscom and a branch of a major Swiss bank which has only been communicating with the data centre via SCION since August 2017. "To the best of our knowledge, SCION is the first newly proposed Internet architecture to go into productive use," explains Adrian Perrig, Professor and Head of the Institute of Information Security at ETH Zurich. His concept is based on what are known as isolated domains, i. e. regionally independent conglomerations consisting of multiple autonomic networks, which have been unified into a joint set of regulations. Large corporations as well as countries can create an isolated domain and set themselves apart in that manner. The ETH researcher explains that it "enables them to protect themselves against external faults and attacks." "Astonishingly, routing and forwarding in SCION is even more efficient than it is in the current Internet, despite the enhanced security features." For example, the routes which the data packets travel from the transmitter to the receiver are defined in advance, which makes it impossible for the data to be diverted.

What is important for the application is that SCION barely requires any new infrastructure. "It only requires



A participant proudly demonstrates how she can draw with a drawing app that she programmed herself on a smartphone in the workshop.
(Photo: Murielle Gerber/EPFL)

a few SCION routers at the edges of the network; the internal connections remain," explains Perrig. "In other words, we need the same roads but are travelling in different cars." The software for the new, more reliable Internet is available as open source software. "Our aim is for SCION to go into use worldwide," says the researcher, explaining why they have decided not to apply for a patent, which could scare off possible users. However, he has founded a spin-off company together with Prof. David Basin and Prof. Peter Müller which is intended to support users.

"DNA data is not a toy"

A secure network is especially important when it comes to exchanging sensitive personal data. "Genomics will become the next big challenge for the protection of privacy" Jean-Pierre Hubaux, Professor at the Faculty of Information Technology and Communication Systems at EPFL, has revealed. He was involved in data protection in mobile networks when two geneticists confronted him with the opinion that "there are more important things to do!" six years ago. They bemoaned the fact that even though DNA sequencing is largely on the increase, there is virtually nobody seeing to the protection of this sensitive data. Hubaux, who had studied information technology, took on this challenge, brushed up on genetics and and is now one of the world's leading experts in the protection of genetic data.

Hubaux is managing a project within the scope of the ETH Domain's initiative on "Personalized Health and Related Technologies" which is intended to ensure data protection when patients' details are exchanged between hospitals and research institutions, as envisaged by the Federal Government's "Swiss Personalized Health Network" (SPHN) initiative. "We have already developed some software packages," explains the project manager. The experts now have to test how to integrate the solutions into the hospital environment. "We have a geneticist in our consortium to guarantee that our work can be used. In addition, I communicate frequently with the IT specialists in the hospital. That is an exciting dialogue."

The exchange of patients' genetic data will facilitate personalised cancer treatment, in particular. With an understanding of the DNA mutations which are linked to certain types of tumours and with knowledge of which type of treatment has been the most successful in each case, this experience can be applied on a targeted basis in the treatment of new patients. However, the genetic data is particularly sensitive as it can be used to unambiguously identify a person. Since relatives share similar genetic material, a person's own DNA may also reveal information about family members. "DNA data is not a toy," Hubaux warns. "It contains information about serious illnesses. We are talking about life and death."

Innovative impetus for skin research

Skin is the subject of a major project called SKINTEGRITY, involving a collaboration between ETH Zurich, the University of Zurich and university hospitals. Co-leader, cell biologist Sabine Werner is working with engineers to investigate the molecular mechanisms of wound healing and the parallels with the development of cancer.

"I have been at ETH Zurich for eighteen years and I have enjoyed being here since day one," explains Sabine Werner. "However, SKINTEGRITY has given my research a further, strong boost." The ETH Professor leads the flagship project being undertaken by the "University Medicine Zurich" network in which twenty-six research groups are exploring the causes of skin diseases and disruption to the healing of wounds and are developing new diagnostic procedures and therapies. Her co-leader is Lars French, Professor and Director of the Dermatological Clinic of Zurich University Hospital.

The research network is a bottom-up initiative, started off by Sabine Werner and her colleague Edoardo Mazza, Professor of Mechanics at ETH Zurich, with the oversight and substantial support of the Vice-President of ETH Zurich, Detlef Günther. The founder explained that you could sense the great enthusiasm and shared chemistry between the people involved right from the very first workshop. Many of the researchers had never worked together before. Sabine Werner added that "I had not realised how much interest and, more especially, how much expertise there was in the skin sector in Zurich".

Since SKINTEGRITY launched in October 2016, many interdisciplinary projects have been undertaken which would otherwise not have come about. For example, researchers who developed artificially grown skin for transplant at Zurich Children's Hospital in previous years are collaborating with engineers at ETH to build a machine which automatically produces replacement skin. The involvement of the Department of Engineering of ETH Zurich in SKINTEGRITY makes the network project unique. "That is our strength and it is innovative," explains Sabine Werner.

Promoting the healing of wounds

In a SKINTEGRITY sub-project, the cell biologist has been working with engineer Edoardo Mazza to investigate how mechanical forces influence the healing of wounds. Observations on patients have shown that wounds heal less effectively when they are exposed to mechanical stress. At the same time, certain mechanical forces would appear to be necessary to maintain the healing of wounds. By identifying their mechanical and cell-biological characteristics, the researchers are seeking to identify which forces promote the healing of wounds and hope to be able to apply their findings in therapeutic practice in future.

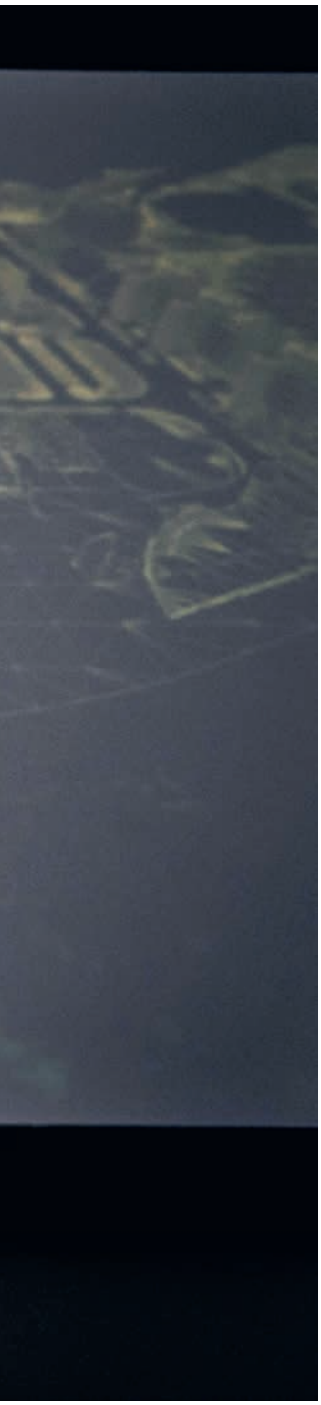
Sabine Werner's area of specialisation is the process of tissue regeneration. Her research group identified a series of growth factors which are released following a skin injury. The team was able to demonstrate how these factors affect each other, coordinating the cells during the wound healing process. There are parallels with the development of cancer. "Cancer utilises the mechanisms of wound healing to advance its own growth," explains the expert. Liaising with researchers from Zurich University Hospital, she is investigating the similarities or differences between individual cell types in wound healing and in the development of cancer. Her research is conducted using tissue samples from a bio bank which is being set up as part of SKINTEGRITY. As the ETH Professor explains, "this is material which we would otherwise never have had access to", stressing the fact that this is only done with the consent of patients, of course, and has been approved by the Ethics Committees.

SKINTEGRITY has received start-up financing contributions of half a million francs each from ETH Zurich (including the ETH Zurich Foundation) and from the University of Zurich. Some of the research network's projects are now also receiving support from a variety of foundations. The skin research being carried out in Zurich has also come to the attention of industry. For example, an initial collaboration has been started with a biotech firm. Other interest has been shown by companies at home and even in the United States. Sabine Werner is particularly delighted to have received applications from doctoral candidates and postdocs from all over the world who wish to be involved in SKINTEGRITY. By bringing together biology, engineering and hospitals, young researchers can receive training at the crossover points between those disciplines. "They are our scientific researchers of tomorrow," explains Sabine Werner.

Prof. Frédéric Kaplan, Head of the Venice Time Machine project (left) and his research employee Isabella di Lenardo.

History goes digital: Virtual time machine allows you to step back into the past

At EPFL researchers are working together with colleagues from Italy on the construction of a time machine that will allow you to immerse yourself in the Venice of the past. The team, headed by Frédéric Kaplan, has digitised two million documents and images for this purpose. Specially developed search engines are bringing this digital heritage to life.



"Recently, I was standing on the Rialto Bridge in Venice in front of one of the tourist shops and couldn't help thinking that in 1740, in this exact spot, Francesco Raspi's bottega was selling clothes, just as his grandson of the same name did decades later", explains Frédéric Kaplan. "Being able to walk around the city and feel a connection with the spirit, life and achievements of a person from the past makes quite an impression on you." Soon, however, this is something that anyone may be able to experience.

Frédéric Kaplan is Professor of Digital Humanities at EPFL and head of the "Venice Time Machine" project. As part of this project, over 20 collaborators are digitising historical documents at the Venice city archives, at the Fondazione Giorgio Cini and the public libraries in Venice. The city archive alone covers a period of 1,000 years and fills 80 kilometres of shelves. In less than two years the team has already managed to scan two million documents, maps and images. For some of these it has used a specially developed scanner with a rotatable, two-metre-wide table that can be fed with several A3 documents simultaneously. This is the fastest machine of its kind in the world and can process up to 8,000 images a day. "We are dealing here with 'dark matter' – documents that hardly anyone has studied before us", says the computer scientist.

Search engines are making this digitised historical material accessible. A system known as "Replica" analyses images and finds pictures of St Mark's Square, for example, even if these have been captured from different perspectives, or recognises scenes in different styles, but of the same genre. Frédéric Kaplan demonstrates how, in a matter of seconds, "Replica" finds all paintings containing a previously selected element – such as the infant at the feet of the Madonna – and regroups the paintings on the basis of this information. This is made possible by means of a technique known as deep learning, which has revolutionised data processing in recent years.

Linking historical sources

A second search engine known as "Linked Books" finds links between archived documents, books or articles. With the help of a robotic scanner that automatically turns the pages of books, the researchers have digitised 3,000 volumes about Venice. This means that all the bibliographic entries in which a document is cited or, conversely, all cited documents in a secondary source can be found. Once historians have tested these search engines, they will be made publicly accessible in 2018.

One of the most difficult tasks is the automatic recognition of old handwriting. As part of a European project known as "READ" the researchers have developed a technique that uses deep learning to recognise whole words. This means that documents are analysed and their key characteristics – information such as names and places – are linked graphically. These documents form the core of a social network to which further documents can be added almost without limit – a Facebook of the past that allows the lives of countless tradesmen, merchants and officials to be reconstructed.

"Our time machine will change research by facilitating and democratising access to historical sources", says Kaplan. It is especially important that young people in particular realise there was also a world before Google. Nevertheless, there has also been some criticism, with certain people warning about the possibility of digital data being manipulated or expressing fears that finding out about our ancestors could have a negative impact on our own lives. "That's the biggest challenge", according to Kaplan, "namely, how our society deals with this development." Similar projects are already being planned in Paris, Budapest and Jerusalem. In addition, a consortium made up of 15 other institutions in addition to EPFL is applying to the European Commission to be selected as the next flagship programme with a view to constructing a European time machine. "It's all about bringing history into the digital world", the inventor of the "Venice Time Machine" sums up.

Storing power in gas

"Power-to-gas" is the name of the concept aimed at connecting the power network to the natural gas network. Researchers at the Paul Scherrer Institute hope that it will enable solar and wind energy to be stored longer. Collaborating with industrial partners, they are testing procedures under real conditions on a platform with containers packed full of high-tech equipment.

On the site of the Paul Scherrer Institute (PSI) in Villigen, the future of energy is housed in six white containers, which are lined up on a platform called "Energy System Integration", or "ESI" for short. The containers consist of compact, state-of-the-art systems. They can be used to produce hydrogen and natural gas, and the hydrogen can be converted back into electricity in the fuel cells if needed. There are tanks beside it containing hydrogen, oxygen and carbon dioxide, which are connected to the platform. The board in front lists the names of over twenty project partners, users and support institutions, including the ETH Board, EPFL, ETH Zurich and Empa, as well as the new site of the Swiss Innovation Park, PARK INNOVAARE, which is located close by, and Swissgrid, the electricity network operator.

"The conversion of electricity into hydrogen or methane is central to the ESI platform," explains Peter Jansohn, Head of Energy System Integration at the PSI. If nuclear power is to be replaced by renewables as part of the government's 2050 Energy Strategy, new storage facilities will have to be developed. Solar and wind energy do not only deliver power when it is actually used. The potential of pumped storage hydro power stations has already been exhausted in Switzerland, and batteries are not suitable for storing energy over long periods. Peter Jansohn explains that "If photovoltaic systems and wind turbines are developed as expected, in future we will have to store several terawatt hours of energy in the summer to use in the winter."

The surplus, electrical energy is to be used to produce chemical sources of energy, a concept known as power-to-gas. Therefore, one of the ESI containers houses an electrolyser, which splits water into hydrogen and oxygen. The plant has an output of 100 kilowatts. "Consequently, it is big enough to only require one further scaling step to make it suitable for commercial use", explains the Head of the ESI.

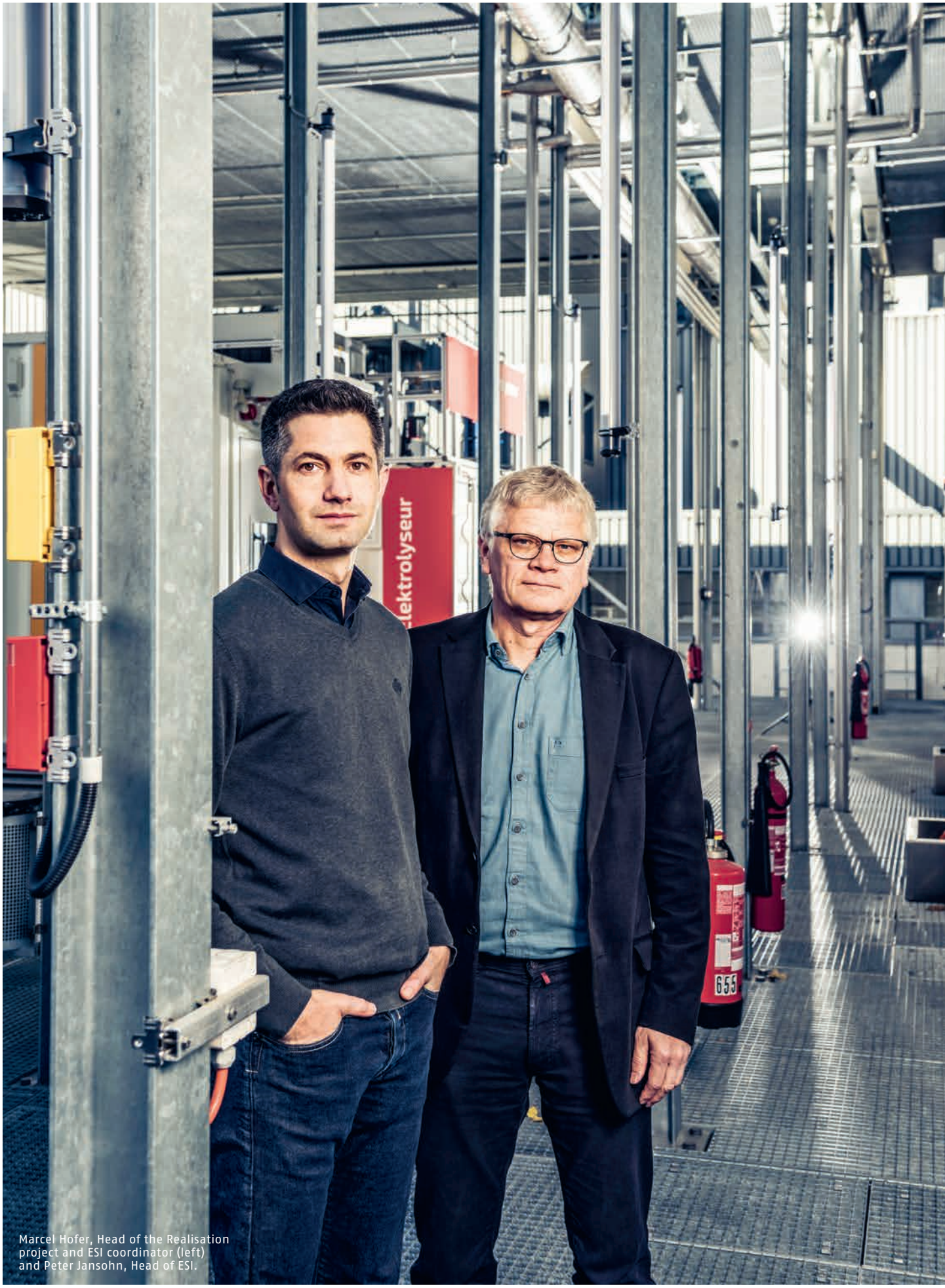
A fuel cell system in one of the containers opposite, in turn, produces electricity from the gases. This can be deployed on a stationary basis for a household energy supply, for instance. A fuel cell can also power a vehicle electrically. In the case of both the electrolyser and the fuel cell system, the PSI is using technology with which it has decades of experience. At the heart of the systems are cell stacks with a polymer electrolyte membrane (PEM). In addition, the fuel cell system is operated with pure oxygen instead of air, a process which was developed at the PSI and which is particularly efficient.

There's even potential in using biomass

The PSI researchers also produce methane from the hydrogen using carbon dioxide from the tank beside the platform. This artificial, CO_2-neutral natural gas can be stored with excellent results and can be fed directly into the existing Swiss pipeline network. "The natural gas network itself acts as a reservoir because the pressure can be varied seasonally, easily enabling it to accommodate several terawatt hours," explains Peter Jansohn. "Consequently, we regard the power network and the natural gas network as a perfect, complementary pairing."

The methanation plant on the ESI platform has already been put to major external use. In January 2017, Cosyma ("Container-based system for methanation") was lifted by crane through a gap in the platform roof, loaded onto a transporter and taken to the Werdhölzli fermentation and sewage-treatment works (project partner is Energie 360°) in Zurich. During 1,000 hours of continuous testing, Cosyma produced 60% more biogas from biowaste than conventional methods. The secret: hydrogen is fed into a fluidised-bed reactor where it combines with carbon dioxide that is contained in the raw biogas. This creates biomethane which can be fed directly into the natural gas network. In January 2018 the Federal Office of Energy (SFOE) awarded the PSI and Energie 360° with the Watt d'Or in the "Renewable energy" category.

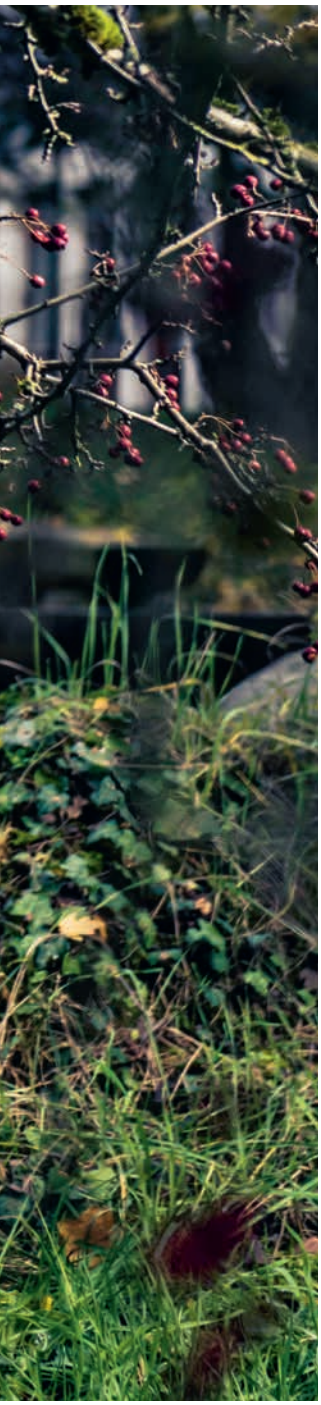
Cosyma has been returned to the PSI in the meantime, and Peter Jansohn is taking stock: "Biomethane production is such an efficient process that the method has great potential to be put into practical application." It would enable about 100 sewage-treatment plants in Switzerland to produce green methane.



Marcel Hofer, Head of the Realisation project and ESI coordinator (left) and Peter Jansohn, Head of ESI.

Genetics for conservation

How can genetic information be used to plan green bridges over motorways more effectively or to prove the presence of a rare species of newt in a pond without any sightings of the animal? Researchers at WSL are using genetics as an effective conservation biology tool, and are making the new techniques practical for users.



Motorways dissect the habitats of wild animals. Green bridges are intended to ensure that the animals can move around widely along their traditional routes again. But do these expensive structures really enable this to happen? Direct observations on green bridges prove that deer cross from one side of the motorway to the other, and animals fitted with transmitters show which routes individuals take. But this data capture does not allow conclusions to be drawn as to whether any exchange takes place between populations over large distances.

"Genetics can be used to answer this question," explained Rolf Holderegger, member of the directorate of the Swiss Federal Institute for Forest, Snow and Landscape Research WSL. To do this, the experts analyse samples of deer which have been hunted or run over, as well as droppings. Applying routine genetic methodology, the sort used in medicine, it is possible to determine how the genetic material of individual animals and of entire populations differs. "The more genetically different the populations are, the less exchange there has been," explained Rolf Holderegger summing up. Therefore, genetic patterns can be used to estimate the wide-scale success of green bridges and to improve planning.

"While genetics will not displace other conservation methods, it can provide vital help in solving many problems," pointed out the Head of the WSL research unit on "Biodiversity and Conservation Biology". The new methodology in conservation is still being used chiefly by research institutions, although Rolf Holderegger is convinced that the time has come for the technology to be transferred over to the private sector. WSL is also an academic partner of the CTI "Toolbox for Conservation Genetics" project. Rapperswil University of Applied Science of Technology (HSR) is developing suitable working practices for the application of genetic methodology in conservation within the scope of that project.

On the trail of rare species

The purpose of these practices is to make it easier for the Swiss government and the cantonal authorities, as the contracting authorities, to make use of genetic methodology in conservation. WSL is being joined in the project by the University of Zurich, a firm of ecology consultants and a DNA analysis company. "The Swiss government and the cantonal authorities are taking a great interest," said Rolf Holderegger, who has also published a manual on conservation genetics for practical application. One of the modules of the CTI project is geared towards simplified techniques for recognising species in rivers and lakes.

If anyone wished to know which frogs or newts live in a pond, an amphibian specialist used to have to go on repeated observation tours. All it takes now is a small sample of water. It contains the genetic material of all the creatures that live or have died in the pond, including the phlegm and droppings of frogs and newts. The experts filter out fragments of DNA in the lab that are specific to amphibians but which vary from one amphibian species to the next, and they duplicate them. This gives them a list of different DNA fragments which they compare against reference data. They can tell from that which species of amphibians exist in the pond. Rolf Holderegger explained that "it allows you to prove the presence of rare newts which are very difficult to observe." This barcoding also reveals whether the chytrid fungus, which poses a danger to amphibians, occurs in the pond which is being studied.

Individuals can also be identified from dropping or saliva samples. Genetic fingerprinting reveals which bear was seen in Switzerland, or whether a sheep was mauled by a wolf or a dog. It can also be used to record the population size of rare, timid species, such as the capercaillie. Observers used to have to count the numbers of birds in places where they congregated to mate. Droppings can now be collected within a particular area whether or not it is mating season. It allows you to find out how many individuals exist, at least. "The number determined genetically is usually much higher than the number observed," said Rolf Holderegger.

When your back hurts

Researchers at Empa are investigating the biomechanical causes of pain in the lumbar region. The forces which put a strain on the back can be identified by combining computer simulations with 3D X-ray videos. The objective is to plan operations more effectively and to develop new implants.

"We are mechanical engineers and we want to know how the joints in the spine work," explained Ameet Aiyangar, who is studying the human locomotor system at Empa using an innovative method. He does this by performing computer simulations that demonstrate the distribution of forces in the back when a person lifts a load. How well these calculations reflect reality depends significantly on how accurate the inputs to the computer model are. "And that is what the problem has been up until now," said Bernhard Weisse, Head of the Biomedical Engineering and Structural Mechanics research group in the Mechanical Systems Engineering department at Empa.

How do the individual vertebrae move in relation to one another when a person bends down and lifts a load? The precise nature of this was unknown up to now because it was impossible to measure the dynamic movement of the bones directly. All they had at their disposal was static X-rays. "We needed a partner in order to improve the quality of the inputs for the simulations," said Ameet Aiyangar, who used to work at the University of Pittsburgh and who is now supported by an Ambizione grant from the Swiss National Science Foundation (SNSF). He was involved in the construction of a unique 3D X-ray video system, the Digital Stereo X-Ray (DSX), in the US, which enables the movements of the spine to be visualised. Therefore, it seemed obvious to nurture cooperation between Empa researchers and the University of Pittsburgh.

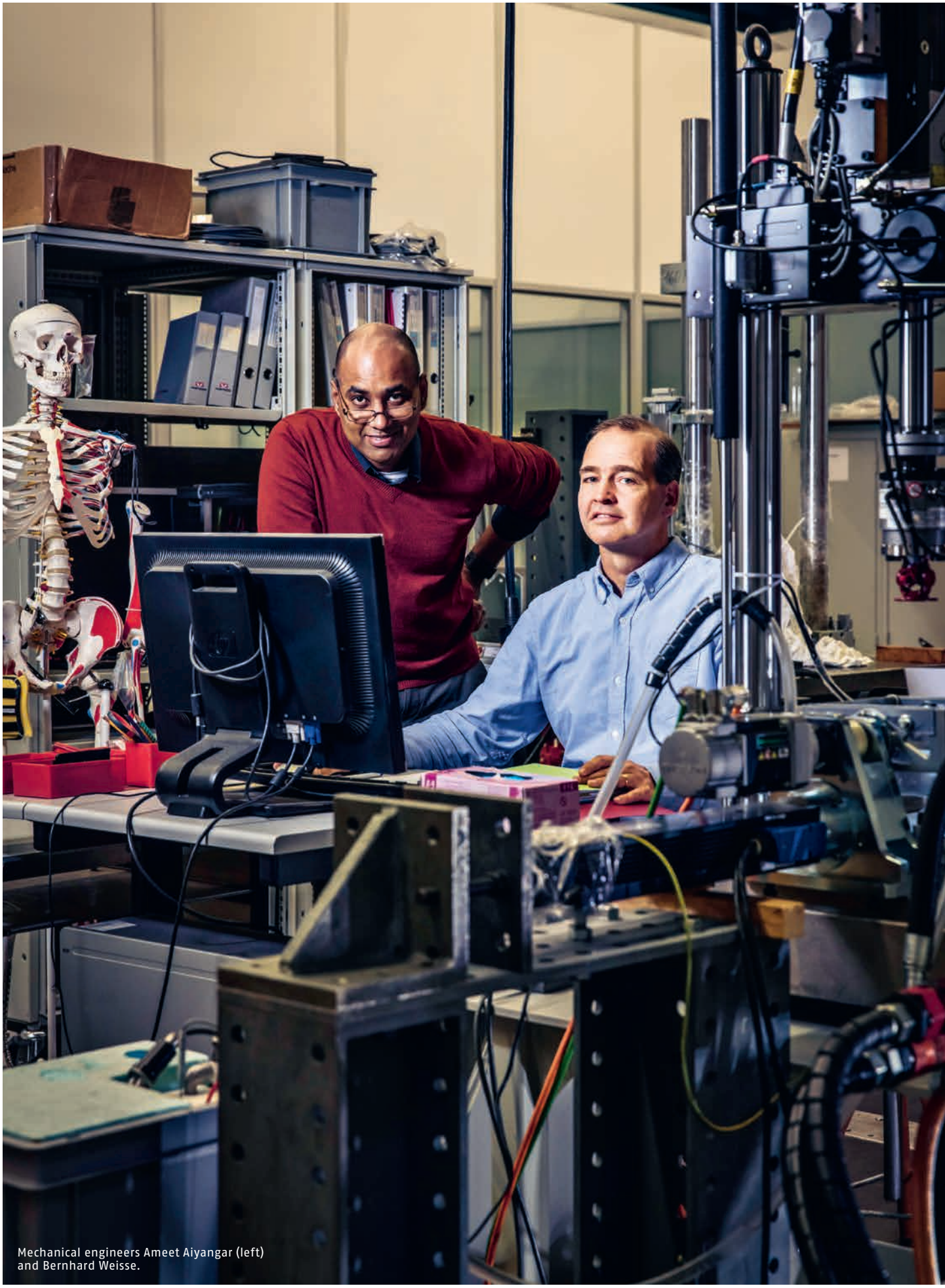
The research group examined twelve healthy adults using the special apparatus in Pittsburgh. The test subjects were required to lift loads of between 4.5 and 13.5 kilograms. The apparatus recorded the process, which each lasted about two seconds, from two directions at 30 frames per second; the X-ray radiation dose was very low. "This allows us to see how the bones move in relation to one another with a degree of accuracy of 0.2 millimetres," Ameet Aiyangar revealed. In a follow-up project, DSX measurements were performed on ten patients before and six months after spinal surgery.

Centres of rotations migrate

The X-ray videos reveal something astonishing: the migration of the centres of rotation around which the lumbar vertebrae rotate when bending and straightening. Translational movements can now be measured very accurately, which is especially beneficial to people with back problems. The engineers observed that the test subjects experienced translational movements of up to ten millimetres during a 75° bending movement; this was rather more in patients with degeneration, although the migration path of the centres of rotation is very irregular. When the Empa researcher fed this data into his simulation program, the displacement in the internal forces had an even greater effect. "Translational movements within the joints had been ignored previously," explained Ameet Aiyangar, "but our simulations show that the migration of the centres of rotation has a significant bearing on the forces in the intervertebral disc."

The engineer performed his calculations using software from the University of Stanford which he has adapted. Based on the calculated distribution of forces, he uses a second simulation method to determine the local stress on the intervertebral discs in the lumbar region and compares the result with the values measured. "The combination of experimental data and computer simulations is the innovative aspect of this study," Bernhard Weisse explained. "This enables us to verify the results." This is decisive for the implementation of the results in the treatment of back patients.

If movement therapies and painkillers no longer help, spondylodesis is often performed, i. e. vertebral fusion surgery. However, the problems often return a few years later because the surgery has increased the stress on the neighbouring segments of the spine. "We hope that our research will help with the planning of surgical intervention in the next five to ten years," said Bernhard Weisse. Patients could benefit from more individualised and targeted treatment from doctors – in keeping with the idea of personalised medicine – and doctors could identify those cases where vertebral fusion is less advisable or where it would make sense to insert a special implant. However, the findings could also help in the development of new disc prostheses which are better at simulating the natural movement patterns of a healthy back.



Mechanical engineers Ameet Aiyangar (left) and Bernhard Weisse.

Heating and cooling with lake water

Lakes and large rivers have huge heat potential which can be tapped into without posing any harm to the environment. This is demonstrated by studies conducted at Eawag. The water research institute of the ETH Domain advises authorities on using energy as cleanly and as sustainably as possible.

Zurich town hall was heated with water from the Limmat as far back as 1938. Nowadays, four lake water networks around the Lake Zurich basin deliver heating and cooling to the surrounding buildings; Lake Geneva is a heat source for heating and cooling the campuses of EPFL and the University of Lausanne, as well as the UN building in Geneva. However, they are just isolated examples. "The technology has long since existed, but even though it has become much more efficient in the meantime, it is still under-utilised," explains Alfred Wüest, Professor at EPFL and specialist in Aquatic Physics at Eawag.

The principle is the same for using of terrestrial heat. A heat pump draws energy from the environment in order to heat a building which is connected to it. While there is limited terrestrial heat potential in areas which are densely populated, there is an inexhaustible reserve of heat on the very doorsteps of the residents of many Swiss cities thanks to the lakes and major rivers. In addition, cooling lake or river water can be fed directly through the buildings in summer. Free-cooling enables temperatures to stay pleasant without having to use air-conditioning systems, which are heavy energy consumers. The Swiss National Supercomputing Centre (CSCS) is one of the world's most energy-efficient computer centres thanks to the 6° cold water drawn from the depths of Lake Lugano.

Alfred Wüest and his team have conducted detailed studies into the physical and ecological effects of using lake water. Eawag researchers have based a scenario for Lake Constance on the assumption that there are a million residents connected to the lake's water networks. "Even then, intervention is extremely small compared to global warming," the expert points out, in summary.

No adverse effect on ecology

While the extraction of heating energy in the winter to heat buildings may even help to counteract climate change, bodies of water should not be heated any further by waste heat from cooling in the summer. Therefore, experts recommend that warmed water be returned into Lake Constance at a depth of greater than 20 metres. In contrast to the surface and the depth range, the water temperature changes quickly the further down one goes into this so-called thermocline. Calculations show that even with intensive use of heat, there is only a slight increase in the thermocline in Lake Constance. Alfred Wüest explains that "it only causes a slight shift in environmental conditions, but nothing new is generated so there are no environmental concerns about using lake water."

The studies conducted by Eawag prompted the International Commission for the Protection of Lake Constance to relax the guidelines on the use of the lake's water. A new housing development with 165 apartments in Romanshorn is now set to be heated with water from the lake. The amazing thing is that even a frozen lake in the depths of winter still supplies environmentally friendly heating energy. For instance, in St. Moritz at an altitude of 1,800 metres. Since 2007, the Badrutt's Palace Hotel and a number of houses have been heated with a heat pump which cools water from Lake St. Moritz from four to one degree Celsius.

One of the largest projects is planned in Lucerne. Drawing water from Lake Lucerne, the Energie Wasser Luzern (EWL) energy company is aiming to supply 100 GWh of heating energy and 23 GWh of cooling energy every year. 40,000 people could benefit from this. The overall potential is many times higher and is far in excess of the realistic demand, as Alfred Wüest ascertained in calculations for the Lake Lucerne Supervisory Commission. Construction work is due to get under way on the first phase in Lucerne in 2018. According to EWL, the overall project will entail an investment of around 95 million francs.

"While the investment costs are high, it will be cost-efficient to run after that," explains Alfred Wüest. He estimates that heating with thermal energy from the lake is currently about twice as expensive as burning cheap crude oil. The expensive cost of tapping into the system is the reason why lakes and rivers are still not widely tapped as a source of clean and sustainable heating energy.

Governance

The Confederation specifies the constitutional mandate to run the Federal Institutes of Technology in the ETH Act. This statute also regulates the legal foundations for operating the research institutes of the ETH Domain.

ETH Domain

11 members
Staff: 51 employees*

ETH Board

Federal Institutes of Technology

over 20,000 students
11,445 employees*

ETH Zurich

over 10,600 students
5,989 employees*

EPFL

Research institutes

2,059 employees*

PSI

488 employees*

WSL

966 employees*

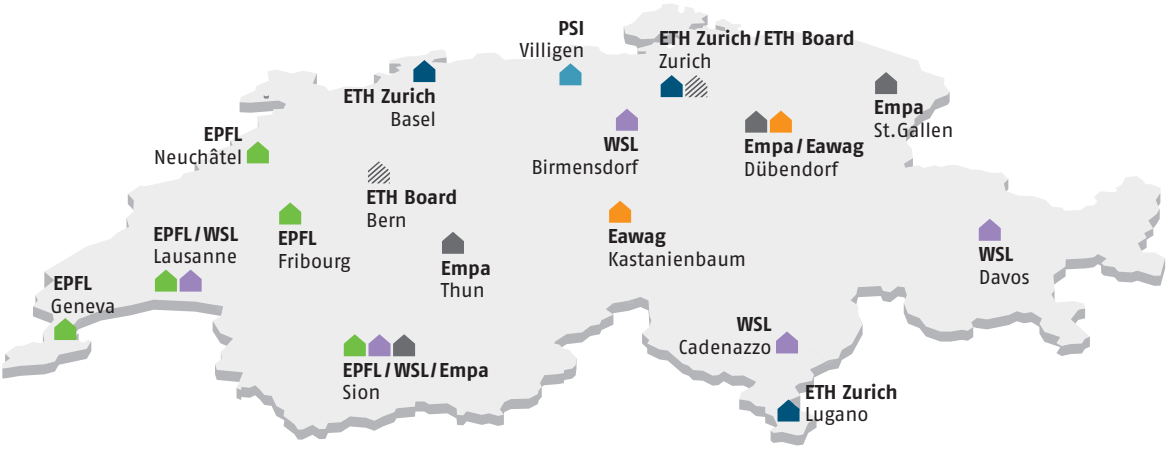
Empa

492 employees*

Eawag

*Employment contracts including doctoral students as of 31 December 2017

ETH Domain: wide anchorage in Switzerland



Contents

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 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 both Federal Institutes of Technology and the four research institutes. The ETH Board is the strategic governing body of the ETH Domain.

Tasks and leadership

According to the objectives set out in Art. 2 of the ETH Act, both 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;
- make use of their research findings.

The institutions of the ETH Domain perform their duties in accordance with internationally recognised standards. They take account of Switzerland's needs and promote international cooperation.

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, as such, is responsible for implementing the specifications.

The political leadership rests with the Federal Council and the Federal Parliament. The central leadership tools are the federal resolution on the four-year financial framework for the ETH Domain, which is passed by Parliament within the scope of the Federal Council's Dispatch on the Promotion of Education, Research and Innovation, (ERI Dispatch 2017–2020), the corresponding strategic objectives set by the Federal Council for the ETH Domain (new from 2017 in place of the performance mandate), and the annual credit allocation from Parliament. These political tools are supplemented by financial controlling, which provides information on accounting and mission fulfilment. The common principles for managing 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. According to the new provisions, the Federal Council will pass the strategic objectives of the ETH Domain. 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 Federal Council's Corporate Governance Report of 13 September 2006 and of 25 March 2009 (Supplementary Report) will be implemented in the ETH Domain. In addition, it 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 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. The self-evaluation report of the ETH Board 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 appli-

cation for funding for the next performance period, the EAER informs Parliament on the status of the achievement of goals in an interim report (Art. 34*a* ETH Act) produced during half of 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 of Technology 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 para. 3 of the ETH Act, the institutions of the ETH Domain assume all responsibilities 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 funding on the basis of the institutions' budget requests. It submits requests to the Federal Council for the selection of the Presidents of both Federal Institutes of Technology and of the Directors of the four research institutes. It also appoints the other members of the Executive Boards of both Federal Institutes 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 agreed targets, annual discussions (known as dialogues) between the ETH Board and the institutions within the scope of strategic controlling, 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.

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 2017, the President of the ETH Board received a salary of CHF 285,592 (the employer also paid social insurance contributions amounting to CHF 84,160) 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 other six members of the ETH Board who are not employees of one of the institutions of the ETH Domain each received a lump sum of CHF 20,000 in 2017. In addition, they were paid a total of CHF 55,000 for dialogue meetings and Audit Committee meetings (including a lump sum of CHF 6,000 for chairing the Audit Committee and for 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 scope of a 70% FTE position, the ETH Board covered

Presidency and Members of the ETH Board
- Dr Fritz Schiesser[1], President
- Prof. Dr Paul L. Herrling[2], Vice-President
- Prof. Dr Lino Guzzella[1]
- Prof. Dr Martin Vetterli[1]
- Prof. Dr Joël Mesot[1]
- Dr Kristin Becker van Slooten[1]
- Marc Bürki
- Beatrice Fasana
- Prof. Dr Dr h. c. Barbara Haering[2]
- Beth Krasna[2]
- Christiane Leister

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

At the end of 2017, Prof. Dr Paul L. Herrling stepped down as Vice-President of the ETH Board. Beth Krasna replaced him as the new Vice-President of the ETH Board in January 2018; Prof. Dr Susan Gasser became a new member of the ETH Board (see p. 37), and Marc Bürki became a member of the Audit Committee.

Executive Board of ETH Zurich
- Prof. Dr Lino Guzzella, President
- 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 Education
- Prof. Dr Andreas Mortensen, Vice-President for Research
- Prof. Dr Marc Gruber, Vice-President for Innovation
- Dr Etienne Marclay, Vice-President for Human Resources and Operations, as well as acting Vice-President for Finance (until the end of January 2017)
- Caroline Kuyper, Vice-President for Finance (since February 2017)
- Prof. Dr Edouard Bugnion, acting Vice-President for Information Systems

Directorate of the PSI
- Prof. Dr Joël Mesot, Director
- Dr Kurt N. Clausen, Deputy Director (until the end of April 2017)
- Prof. Dr Alexander Wokaun, Deputy Director (until the end of December 2017)
- Prof. Dr Gabriel Aeppli, Member
- Dr Peter Allenspach, Member
- Prof. Dr Andreas Pautz, Member (since May 2017)
- Prof. Dr Leonid Rivkin, Deputy Director (since May 2017)
- 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

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 (since October 2017)
- Prof. Dr Alfred Johny Wüest, Member
- Dr Christian Zurbrügg, Member

Status as at 31 December 2017 (reference is also made to changes agreed in 2017 which will become effective in 2018).

40% of the wage and social costs (including compensation for expenses) incurred by EPFL for the delegate of the University Assemblies of both Federal Institutes of Technology, in order to guarantee this delegates' independence from either institution.

Monitoring and audit

Internal control system
The institutions of the ETH Domain have an internal control system, which was introduced in line with Federal regulations. The Swiss Federal Audit Office (SFAO) can thus audit the accounting system and finance-related business processes using the same methods as for other Federal institutions or private sector enterprises of comparable size.

Internal audit
The Internal Audit department conducts internal audits for the institutions of the ETH Domai (Art. 35*a*^{bis} 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. 35*a*^{bis} para. 3 of the ETH Act). In 2017, 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 Pricewaterhouse-Coopers (PwC). The SFAO's audit report on the consolidated financial statement 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 2017 the SFAO invoiced the ETH Board for the total amount of CHF 562,272 (CHF 325,237 for the 2016 annual review and CHF 237,035 for the interim audit of the 2017 annual financial statement).

Information policy
Its statutory role makes the ETH Board an interface between science, politics and society. According to 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 and 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
- Beatrice Susanne Vogt, Vice-President (until the end of December 2017)
- 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 staff of the ETH Board support it 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 Urs Müller, Legal Services (until March 2017)
- Dr Monique Weber-Mandrin, Legal Services (since April 2017)
- Michael Quetting, Real Estate
- Barbara Schär, Board Secretarial Office

Internal audit
The ETH Board employs Internal Audit staff, as per Art. 35*a* 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 member of the Foundation Board of the think tank Avenir Suisse, the Swiss Science Center Technorama in Winterthur, and the Swiss Innovation Park.

Paul L. Herrling

*1946, Swiss citizen, Prof. Dr phil.
Member of the ETH Board since 2004, Vice-President since 2008 and member of the Audit Committee since 2012.
Chair Novartis Institute for Tropical Diseases since 2012.

Paul L. Herrling obtained a doctorate in natural sciences at the University of Zurich. From 1996 to 2002, he headed research at Novartis Pharma and from 2002 to 2010, group research at Novartis International. He then led the Novartis Institutes for Developing World Medical Research until the end of 2011. At the University of Basel, he has been Professor of drug discovery science since 2001 and member of the University Council since 2007. In addition, he is on Boards of Trustees in the Novartis Group and in various foundations.

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)

Marc Bürki

*1961, Swiss citizen, Dipl. El.-Ing.
Member of the ETH Board since 2017.
CEO of Swissquote Holding Ltd and Swissquote Bank Ltd since 1999 and 2002 resp.

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 at 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 member of the Board and chairs the Management Committee of the University of Applied Sciences and Arts of Southern Switzerland (SUPSI).

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). She is President of the Council of Foundation of the Geneva International Centre for Humanitarian Demining and the Strategic Direction Council (*Conseil d'orientation stratégique*) of the University of Geneva. Moreover, Barbara Haering is member of the Foundation Council of the Swiss National Science Foundation (SNSF) and the University Council of Dresden University of Technology. In addition, she works as an adjunct professor at the University of Lausanne since August 2016.

Martin Vetterli

*1957, Swiss citizen, Prof. Dr, Dipl. El.-Ing.
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 and from 2011 to 2012, Dean of the Faculty of Computer and Communication Sciences. 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 PSI since 2008, dual Professor at ETH Zurich/EPFL since 2008.

Joël Mesot studied physics at ETH Zurich, obtaining a doctorate in solid-state physics in 1992. In 2002, he was awarded the Latsis Prize of ETH Zurich and in 1995 the Swiss Physical Society IBM Prize. After residing in France and the USA, he came to ETH Zurich and joined 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 expert committees. 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, German/Swiss 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.

Beth Krasna

*1953, Swiss/US citizen, Dipl. Ing.
Member of the ETH Board since 2003 and 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 member of the Board of Directors of Coop, Raymond Weil AG, Symbiotics SA and Alcosuisse as well as President of the Board of Directors of Xsensio SA. Additionally, she is Vice-President of the Foundation Board of the Graduate Institute of International and Development Studies, and member of the Swiss Academy of Engineering Sciences. At the beginning of 2018, Beth Krasna assumed the position of Vice-President of the ETH Board.

Christiane Leister

*1955, German/Swiss 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

Susan Gasser (*1955) is Director of the Friedrich Miescher Institute for Biomedical Research and Professor of Molecular Biology at the University of Basel. She is one of the leading scientists in her field and one of the most high-profile people in Switzerland in the field of life sciences. In addition to her outstanding scientific profile, she comes with a wealth of expertise, thanks to her many years of collaboration with the SNSF, the Swiss Academies of Arts and Sciences and the Swiss Science and Innovation Council, which are of relevance to the science and innovation policy issues facing the ETH Board. Susan Gasser took up her position on 1 January 2018. *(Photo: Nestlé Nutrition Council)*

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

Risk situation and risk management

The six institutions of the ETH Domain are responsible for their own risk management within the framework of the directives issued by the ETH Board in accordance with the autonomy enshrined in the ETH Act. In line with this, the presidents of ETH Zurich and EPFL and the directors of the four research institutes bear ultimate responsibility for risk management in their institutions.

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 both 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 as anticipated, and that functional and innovative capability can be maintained. On the other hand, personal safety and the security of property and other assets are to be guaranteed to the greatest possible extent. The leadership of the two Federal Insitutes of Technology and of the research institutes is to be supported by comprehensive, transparent and up-to-date risk information and risk awareness among students, staff and professors. In addition, 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 covers the identification and evaluation of the individual risks as well as strategies for coping with them and for monitoring them appropriately. The coordination of risk management activities and supervision of the risk management process are ensured 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 and assessed 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 the reputation of the institution. 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 that could lead to significant financial consequences and that have an above-average probability of occurring. They directly endanger the fulfilment of the legal duties of the respective institution. 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 and promptly by the institutions about any extraordinary changes in risk or damaging events.

The individual profile of each institution is reflected in its risk catalogue. Thus, the two Federal Institutes of Technology have different core risks to the four research institutes. The particular orientation and size of each institution also has a bearing on the risks. Therefore, the assessment of the same risk may vary.

Taking on excessive obligations, the risk of a lack of oversight of long-term financial obligations and the consequences of such as well as of the loss of management and control options 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 scientific 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. When assessing this risk, which is subsidiary for the Federal Government, as a contingent liability under Art. 19(1) of the Government Liability Act, the insurance policies taken out by the institutions of the ETH Domain play an important role.

The principles of risk management require that the two Federal Institutes of Technology and the four research institutes take out insurance against possible losses, subsidiary to other measures, where such insurance is feasible and there is sufficient funding. Each institution is responsible for taking out insurance cover and administering its own insurance portfolio. In doing so, it must take into account its specific risk situation and strive for an appropriate cost/benefit ratio and must ensure compliance with the federal regulations governing public sector procurement. These insurance policies must meet the usual standard for the Swiss insurance market. They must be concluded with an insurance institution that is licensed in Switzerland. Therefore, the institutions have taken out property and employers' liability insurance policies as well as smaller insurance policies for specific risks. The properties owned by the Federal Government are not insured, because the Confederation follows a strategy of self-insurance.

Personnel matters of the Federal Council

At the request of the ETH Board, the Federal Council appointed Prof. Dr Gian-Luca Bona to act as Director of Empa for a further four years on 22 February 2017. Under the leadership of Gian-Luca Bona, Empa has developed into a leading international research institute for material research and innovative technologies.

On 5 July 2017, the Federal Council appointed the long-standing board member Beth Krasna as Vice President of the ETH Board. She succeeded Paul L. Herrling, whose tenure finished at the end of 2017. In addition, the Federal Council appointed Prof. Dr Susan Gasser as a new member of the ETH Board. Beth Krasna and Susan Gasser took up their posts on 1 January 2018 (see p. 37).

Personnel matters of the ETH Board

Appointment to the Directorate of the PSI

At the request of the Director of the PSI, Prof. Dr Joël Mesot, the ETH Board appointed Prof. Dr Andreas Pautz as a new member of the Directorate in March 2017. Andreas Pautz was appointed as Full Professor of Nuclear Technology at EPFL at the same time as being Head of the Laboratory for Reactor Physics and System Behaviour at the PSI in October 2012. He took up his position on 1 May 2017.

Appointment to the Directorate of Eawag

At the request of the Director of Eawag, Prof. Dr Janet Hering, the ETH Board appointed Gabriele Mayer as a new member of the Directorate of Eawag in September 2017. Her appointment will particularly strengthen the Directorate in the areas of compliance, corporate governance and administration. Gabriele Mayer has been employed at Eawag, the water research institute of the ETH Domain, and as Head of the Human Resources and Finance departments since 2007. She took up her position on 1 October 2017.

Professorial matters

Refer to the section on key figures for Personnel, p. 104, for information about the appointment of professors.

Strategic objectives

The Swiss Federal Council sets out the strategic objectives for the ETH Domain for the period from 2013 to 2016 including strategic priorities, financial and infrastructural goals as well as personnel-related and pension policy objectives.

Strategic priority

1 Teaching

"The ETH Domain offers students an attractive, research-based education that is first rate by any international standards." → *p. 42*

Strategic priority

4 Knowledge and technology transfer

"In order to reinforce Switzerland's innovative strength and competitiveness, the ETH Domain promotes collaboration and exchange with the economy and society." → *p. 48*

Strategic priority

5 National cooperation and coordination

"The ETH Domain is actively involved in shaping the Swiss university sector." → *p. 58*

Financial and infrastructural goal

8 Sources of financing and allocation of funding

"The ETH Domain is expanding its financing base and seeks to ensure that the funding is used cost-effectively and in compliance with strategies." → *p. 72*

Strategic priority

2 Research

"The ETH Domain is maintaining its leading position internationally in research."
→ *p. 46*

Strategic priority

3 Research infrastructures

"The ETH Domain is involved in the operation and development of research infrastructure." → *p. 50*

Strategic priority

6 International positioning and cooperation

"The ETH Domain will continue to expand its cooperation and networking with the best institutions in the world and strengthen its international profile."
→ *p. 56*

Strategic priority

7 Role in society and national tasks

"The ETH Domain maintains a dialogue with society and performs tasks in the national interest." → *p. 66*

National tasks → *p. 70*

Financial and infrastructural goal

9 Real estate management

"The ETH Domain coordinates the management of the properties and real estate, and ensures the preservation of their value and functionality."
→ *p. 76*

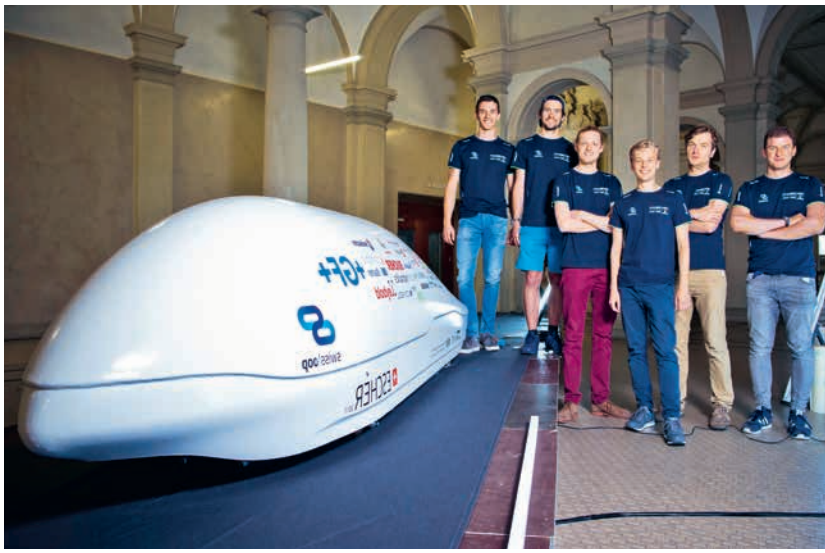
Personnel-related goal

10 Working conditions, equal opportunities and young scientific talent

"The ETH Domain is an attractive and responsible employer."
→ *p. 78*

1

"The ETH Domain is maintaining its leading position internationally in research."



The Swissloop team, made up of students from ETH Zurich and other Swiss universities, came third in the speed competition for revolutionary transport systems put on by Elon Musk in Los Angeles. *(Photo: Mirko Ries Photography)*

The ETH Board's perspective

The two Federal Institutes of Technology, supported by the four research institutes, offer first-class research-based teaching to students and doctoral students. Student numbers were up 3.5% on last year at almost 25,100, while the number of doctoral students rose by 1.6% to around 6,200. Over 850 exchange students, who had previously been counted as Bachelor's and Master's degree students and who were recorded as separate categories from 2017, are testament to how attractive the two Federal Institutes of Technology are. Consequently, they make an important contribution towards the international exchange of students.

New skills-based forms of teaching and learning will be used to equip the students for the future challenges of the working world in the best possible way. For example, the "Student Project House" at ETH Zurich and the "Discovery Learning Laboratories" at EPFL encourage students to learn how to develop innovative ideas and implement them in multidisciplinary teams.

Teaching is continuously adapted to reflect scientific, social and economic developments and needs; it was expanded in 2017 into the two strategic focus areas of Personalized Health and Data Science with the Bachelor's degree course in Human Medicine at ETH Zurich, as well as the Master's degree courses in Data Science at the two Federal Institutes of Technology and in Digital Humanities at EPFL.

The research institutes supplement the courses offered and make a significant contribution towards supervising Bachelor's and Master's dissertations and PhD theses. The cooperation between the research institutes and the two Federal Institutes of Technology has been consolidated further with jointly funded professorships. To promote student exchanges between the institutions of the ETH Domain, the ETH Board supports a programme which was used to a similar extent in 2017 as it had been in previous years: 93 students took advantage of this by spending a semester in a different linguistic region, and 151 students took part in summer schools.

ETH Zurich

In September 2017, 2,918 new undergraduates embarked upon their Bachelor's degree courses at ETH Zurich (+5%). All in all, the number of students and doctoral students at ETH Zurich passed the 20,000 mark for the very first time in autumn 2017. The two new courses in Human Medicine and Data Science (see below) have contributed considerably towards this rise. ETH Zurich also recorded a new highest ever number of applicants for admission onto Master's courses in 2017. 3,586 Bachelor's graduates from other universities at home and abroad applied for a place on one of the 46 Master's degree courses offered by ETH Zurich. The opportunities for mobility were actively taken up by 449 incoming and 244 outgoing exchange students.

ETH Zurich expanded its range of courses in two strategic key areas, Medicine and Data Science. The new Bachelor's degree course in Human Medicine, which has 100 places, is aimed at students who are not only interested in medicine, but also in natural sciences and technology. They had to pass an aptitude test to study Medicine, which is led by swissuniversities. A total of 287 applicants put ETH Zurich down as their first choice when they applied to do the aptitude test. For the subsequent Master's in Medicine, they will switch over to one of ETH Zurich's partner universities after three years. The new degree course was only made possible by the good cooperation with various clinical partners and the universities in Zurich and Basel, as well as the Università della Svizzera italiana (USI) in Lugano.

The new Master's degree in Data Science will be offered together with the departments of Informatics, Mathematics, and Information Technology and Electrical Engineering. The material covered includes the administration and storage of large amounts of data or the development of efficient algorithms for data analysis. The new Master's degree course attracted an extraordinarily large amount of interest; 160 people applied for a place on the course first time around.

Teaching standards at ETH Zurich undergo ongoing review and improvement. The learning success of the students is significantly

influenced by performance certificates such as exams. Therefore, ETH Zurich also relies on examination models which are less concerned with testing knowledge, but are more about stimulating learning. "Learning elements" such as quick exercises, quizzes or solutions to exercises allow the students to draw conclusions about about their own progress in learning and are intended to motivate them to actively follow the lessons during the semester. They complement classical examinations.

The university is seeking to best equip its students for the digitised world and to send them on their way with the right digital skills, such as programming, analysis of data records or the application of a CAD program. With its skills-based online testing system, ETH Zurich is leading the way nationwide and is an important driving force in technical innovation internationally. Therefore, it is aiming to more than triple its capacity to conduct examinations online by 2022.

Ultimately, ETH Zurich is promoting variety in methods of teaching and learning. It is increasingly important for students to develop their own ideas and to learn how to apply them in multidisciplinary project teams. The pilot Student Project House (SPH) – a venue for creative thought and workshops on the Hönggerberg Campus – has provided the space and resources for this since 2017. 25 ETH students developed their own project ideas into prototypes in multidisciplinary groups at the first SPH Innovation Challenge in 2017. "ETH Week" was held for the third time in September 2017, this time on the subject of "Manufacturing the Future". Over the course of the week, 180 Bachelor's, Master's and exchange students from all 16 departments of ETH Zurich found out more about factories, resources and human/machine relations in multidisciplinary and cultural teams. ■

The team from the Extension School. *(Photo: EPFL)*

EPFL

At the start of the 2017 semester, there were 10,686 students and doctoral students enrolled at EPFL (+1% on 2016), of whom 1,817 entered the first year of the Bachelor programme. The areas which showed the highest rates of growth were electrical engineering (+37%) and materials science (+22%). Once again, the areas of mechanical engineering and microtechnology reported the highest numbers of first year students with 257 and 260 respectively.

296 new students from other universities enrolled on a Master's course (up 11% on 2016). Communication systems and life sciences recorded the strongest increases among students on the first year of their Master's degree courses. Informatics has once again seen the highest number of new Master's students (57).

Where students did not successfully complete the polytechnic subjects in the first foundation semester, EPFL ran an advanced course in mathematics and physics in spring 2017. It was attended by around 700 students.

The objective of the Master's degree course in Digital Humanities, which was launched in September, is to connect technology and humanities, promoting cross-disciplinary learning. In addition, a Master's degree in Data Science was created in the Faculty of Computer and Communication Sciences, attended by 65 students. This is also intended to tackle the social challenges of digitisation. Four specific courses were added to the Bachelor's degree in Life Sciences to promote the expansion of links with the Medicine degree course at the University of Lausanne (UNIL).

The first COS (Certificate of Open Studies) course began in summer 2017. It comprises MOOCs which are focused on African cities. In addition, the continuous education programme will be reinforced with the opening of the Extension School, as well as the launch of the first COS last November. It is intended to permit anyone to acquire the necessary skills to profit from the possibilities offered by the digital age.

The Centre d'Appui à l'Enseignement (CAPE) offers a growing number of teachers personal support, by helping with the use and development of new, strictly evaluated pedagogical ideas. 442 teachers availed of its services in 2017.

The services available for doctoral students was extended. More than 200 doctoral assistants took part in teaching workshops. These workshops can count towards the degree course and are recognised by the EPFL doctoral school.

With 406 incoming students and 340 outgoing students, international exchanges are thriving at EPFL. For this purpose, 28 agreements were negotiated or re-negotiated during the reporting year, from a total of 150 international partnerships.

The laboratories for practical inter-disciplinary work (Discovery Learning Laboratories, DLL), which are housed in the Mechanics Building, are very popular. The number of students registered is set to rise from 1,300 in the autumn semester of 2017 to 2,200 in the spring semester of 2018. More than 84,000 teaching hours were delivered there at the interface between electronics, materials science, bio-engineering and optics. Pilot projects involving digital developments and facilitating exchange between the areas make it possible to follow new pedagogical paths through the learning process within the project itself. In order to ensure this, eight interdisciplinary projects were set in motion with around 300 students who identified support needs and demonstrated possible solutions. They also enabled the ongoing prototyping room programme, which had been under development, to be completed. The Molecular-DLL programme, which was developed in collaboration with the UNIL, aimed at the renovation of the Chemistry facilities, has entered the final phase at last. ■

"I work at two renowned institutions, the PSI and ETH Zurich. By pooling our resources in both, we can carry out some really outstanding research," explains Prof. Laura Heydermann. *(Photo: Scanderbeg Sauer Photography/PSI)*

PSI

The PSI provides various teaching courses, largely practical, to support training at the Swiss universities. Numerous employees from the PSI are regularly involved lectures and practical classes at the two Federal Institutes of Technology, cantonal universities, Swiss universities of applied sciences, as well as abroad, delivered a total of approximately 6,500 teaching hours in 2017. In addition to the 310-plus doctoral students and 170 postdocs who are carrying out their research projects at the PSI, over 140 Bachelor's and Master's dissertations were supervised by scientific personnel from the PSI.

In addition to the courses at universities, the PSI regularly organises specific research-linked activities for upcoming young scientists from Switzerland and abroad. A two-week summer school was run for Master's degree students for the first time in September 2017. After attending lectures and workshops to teach basics in the field of materials analysis with spectroscopic methods, the students were then able to perform experiments themselves on the PSI's large-scale research installations (SLS, SINQ, SμS), gaining valuable experience in using these techniques with a view towards undertaking research projects in the future.

The PSI training centre offers a broad spectrum of initial and continuing education programmes in working with ionising radiation for people from medicine, industry, commerce and authorities. In addition to this subject-specific training, the PSI Academy offers numerous courses for employees and particularly expanded its programme in 2017 in the area of transferable skills, personnel management and entrepreneurship.

The 60-plus researchers from the PSI who are also engaged as professors or private lecturers at universities make a special contribution towards teaching. This collaboration evidently benefits both sides; while teaching at the universities is being broadened to include PSI-specific fields of research and examination methodology, the professors and lecturers are also a point of access to the PSI for young researchers or for future users of the large-scale research installations. ■

WSL

WSL staff taught a total of 3,048 hours at the two Federal Institutes of Technology, at cantonal universities, at Swiss universities of applied sciences and at further education colleges abroad in 2017; this lies within the scope of last year's fluctuations. The division between the different universities is similar to previous years: The largest share – about half – took place in the ETH Domain (1,552 ETH Zurich, 373 EPFL). Many WSL employees supervise Bachelor's, Master's and Diploma's dissertations, as well as PhD theses; this amounted to a total of 261 (19/98/2/142) in 2017.

The lectures and courses at WSL complement the courses offered by the universities in subject areas in which (only) WSL has specific technical expertise. Therefore, there are often no standard teaching materials available which lecturers could use. This prompted two of the researchers to write textbooks in 2017, which have been brought out by renowned publishers and which have closed significant gaps; Member of the directorate, Prof. Niklaus Zimmermann is the co-editor of "Habitat Suitability and Distribution Models", and Werner Suter, long-standing lecturer at ETH Zurich for the new intake of environmental scientists and biologists, wrote "Ökologie der Wirbeltiere", a text on the fundamentals of the ecology of vertebrates. Books cannot always cover all needs, which is why WSL lecturers also compile interactive e-learning courses. Prof. Felix Kienast expanded his existing Moodle course in "Landscape Ecology" for ETH Bachelor's degree students into a MOOC; and the MOOC run by WSL director Prof. Konrad Steffen, "The Frozen Frontier: Monitoring the Greenland Ice Sheet from Space", produced by the European Space Agency, has already been successfully conducted and completed by around a hundred students. He is currently working on the preparations for a further MOOC entitled "GlobalArctic" in association with a professor from EPFL, Matthias Finger. Summer schools have also proved to be very popular among students. WSL has been running some for many years, although it is continually developing new programmes. For instance, summer schools on "Polygenetic Adaptation" and on Landscape Research were held for the first time in 2017, attracting participants from around Europe and the wider world. ■

Summer school on "Landscape Research": The range of courses in the area of landscape combine natural and social sciences. *(Photo: Lisa Bose/WSL)*

Federal Councillor Doris Leuthard (l.) and Luca Schaufelberger. *(Photo: Empa)*

Empa

Researchers at Empa make a significant contribution as lecturers to teaching at Swiss and foreign universities; they delivered more than 3,900 lessons in 2017. The vast majority of these hours, some 2,500, took place at the two Federal Institutes of Technology, where nine Empa researchers also hold professorships. Furthermore, 14 Empa researchers have professorships at a Swiss university. Last year, for instance, Empa researcher Michel Calame was appointed as a titular professor of Nano Science at the University of Basel.

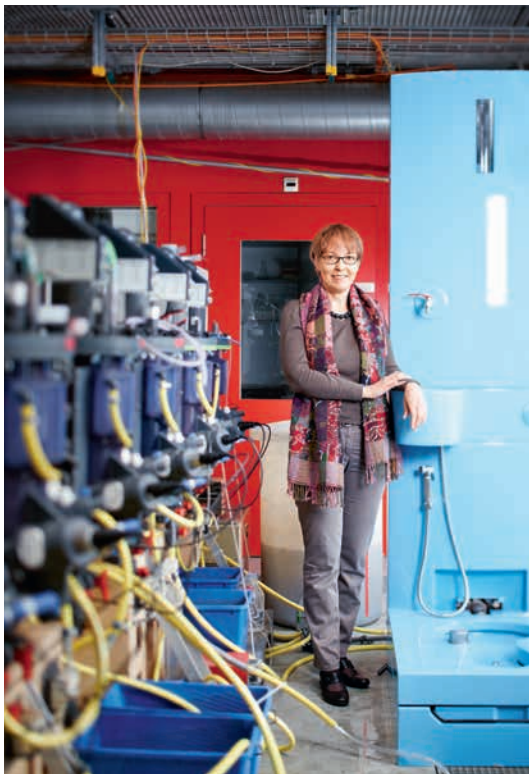
Empa researchers supervised around 160 Bachelor's and Master's degree students, as well as 210 doctoral students in 2017. Empa is also a very active provider of non-university specialist training and continuing education. Around 120 people took part in over 5,500 courses and events organised by the Empa Academy in 2017.

Empa is also very involved in the development of the upcoming young scientists; Luca Schaufelberger, a school leaver from Zofingen Cantonal School, did a placement in the Laboratory for Applied Wood Research at the Empa as part of the extended paper for his examinations at the start of 2017. He was involved in the development of a water filter made from chemically modified nanocellulose, which is ideally suited for removing humic acids from contaminated water, and which is reusable. This is a decisive advantage, as it is far more ecologically sound than disposable versions. The 19-year-old's placement project proved to be so ground-breaking that his work at Empa culminated in two scientific publications. In addition, his extended paper was awarded a grade of "outstanding" from the organisation "Swiss Youth in Science" – and he received an additional prize entitling him to attend the "GENIUS Olympiad 2017" at the "State University of New York" (SUNY) in Oswego on Lake Ontario as the only Swiss representative. This annual competition brings together students from all around the world to compete in environmental projects in five categories. And his reusable nanocellulose filter attracted huge interest, and he was awarded gold in the "Science" category. ■

Eawag

Teaching provided by researchers from Eawag is based on their own current research. Scientists from Eawag contributed significantly to training in environmental nature and environmental engineering sciences in 2017. They taught a total of over 3,000 teaching hours at the two Federal Institutes of Technology. They also undertook a further 1,300 hours of teaching at other universities, mainly at cantonal universities. Eawag researchers supervised 140 doctoral students, around 100 of whom were employed at Eawag, as well as over 170 Bachelor's and Master's theses. In addition to ETH Zurich and EPFL, Eawag maintains partnerships with cantonal universities. They are associated with professorships at the Universities of Bern (Aquatic Ecology and Social Sciences), Neuchâtel (Hydrogeology) and Zurich (Biodiversity and Environmental Psychology). Eawag, operating in association with EPFL, runs four freely accessible Massive Open Online Course (MOOC) in "Sanitation, Water and Solid Waste for Development". More than 42,000 people from 176 countries participated in this in the past three years. A further mainstay of Eawag's teaching activities is its internationally oriented summer schools. A course in "Environmental Systems Analysis" was held for the ninth time in Dübendorf in 2017. In addition, Eawag was involved in a summer school at ETH Zurich and at EPFL on transport processes in water catchment areas.

Tove Larsen, who has been a member of the Eawag directorate since 2014, was appointed as a titular professor at the Technical University of Denmark (DTU) at the start of 2017. She is a group leader in the Department of Sanitary Engineering (SWW) and has been at Eawag since 1999. Tove Larsen represents the Environmental Systems Sciences area in the directorate. She worked as a lecturer at ETH Zurich for eight years. Her links to the DTU stretch back to the start of her career when she graduated in Chemical Engineering from the DTU and did a PhD in Environment there. ■



Prof. Tove Larsen develops new toilet systems with resource recovery. *(Photo: Michael Sieber/ETH-Rat)*

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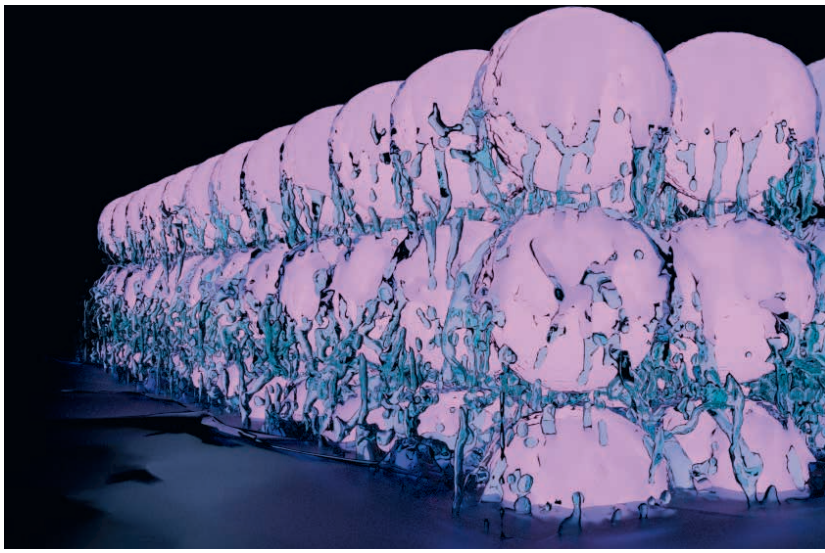
"The ETH Domain is maintaining its leading position internationally in research."



When matter cools close to absolute zero, the properties of a liquid and a solid melt together. ETH researchers have succeeded in demonstrating this suprasolidity experimentally. *(Photo: Julian Léonard/ETH Zürich)*

The ETH Board's perspective

The first calls for project entries for the strategic focus areas of the ETH Domain started in 2017. Researchers from the ETH Domain were able to apply for funding within the scope of the "Personalised Health and Related Technologies" (PHRT) focus area. This focus area is intended to complement the "Swiss Personalised Health Network" (SPHN) national initiative. In addition, the first research projects of the "Advanced Manufacturing" focus area and of the Swiss Data Science Center (SDSC) were selected and started. In the meantime, major events were held to mark the official opening of both strategic focus areas: the SDSC in January and Advanced Manufacturing in November attended by Federal Councillor Johann Schneider-Ammann. With their leading-edge research, the institutions of the ETH Domain have continued to be actively involved in the implementation of the Swiss Confederation's 2050 Energy Strategy. The eight Swiss Competence Centers for Energy Research (SCCERs), seven of them under the management of one of the institutions of the ETH Domain, embarked upon their second phase in early 2017 after their funding for 2017–2020 had been extended.

In addition to creating strategic focus areas and successfully sourcing funds from them, the researchers from the ETH Domain have achieved remarkable outcomes in fundamental and applied research, i.e. in areas such as health, climate change, mobility and urban development, cyber security or nanotechnology. This research is often carried out in collaboration between different institutions from the ETH Domain, as well as with other Swiss and foreign institutions. The outstanding work of the scientists from the ETH Domain is also reflected in the different awards and research grants that they received in 2017, including numerous ERC grants from the European Research Council. ETH Zurich and EPFL also ranked among the best universities in the world in 2017 according to various international rankings.

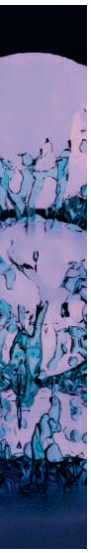
ETH Zurich

ETH Zurich continued to forge ahead with the development of its strategic priorities in 2017. It was a milestone year for medicine at ETH Zurich. The university has been running a Bachelor's degree course in Human Medicine for the very first time since September 2017. All in all, ETH Zurich filled six newly created professorship posts in this area in 2017. Two programmes have been launched which will serve to promote cooperation between hospitals, universities and the ETH Domain: the Swiss Personalized Health Network (SPHN) and the strategic focus area on Personalized Health and Related Technologies (PHRT) at the ETH Domain. The collaboration with the university facilities in Tessin has also been further strengthened in the area of medicine (see p. 42).

The Wyss Translational Center Zurich (WTZ) of ETH and of the University of Zurich is seeing a positive results after only two and a half years. One project has already been successfully completed. Seven of the current figure of nine projects have already seen the creation of spin-offs, some of which have been able to secure significant alternative financing. In addition, four of these projects are also already preparing clinical studies (phase I or phase II).

The Department of Biosystems (D-BSSE) at ETH Zurich in Basel, which was founded in 2007, is a particular success story. It will be celebrating its tenth anniversary in 2017. Focusing its attention on system biology and synthetic biology, D-BSSE has been making essential contributions towards ETH Zurich's strategic focus areas in Medicine and in Data Science. The department currently comprises 19 professorships with over 300 employees. Since 2007, they have obtained 13 ERC grants, founded eight spin-offs and, together with the University of Basel, have been awarded the National Centre of Competence in Research in Molecular Systems Engineering.

The roll-out of the focus area in Data Science also progressed in the year under review. ETH Zurich filled 41 professorships in 2017 and started up a new Master's degree course in that area in the autumn (see p. 42). EPFL and ETH Zurich opened the new Swiss Data Science Center (SDSC) (see p. 10) in February 2017. Within the



scope of the first call for interdisciplinary Data Science projects in 2017, 12 projects were selected, five of them involving researchers from ETH Zurich.

In the field of energy research, ETH Zurich has been able to contribute significantly to the implementation of the Federal Government's 2050 Energy Strategy due to the consistency with which it has developed its areas of expertise over many years. For example, it leads three of the total of eight Swiss Competence Centres for Energy Research (SCCER), whose funding was extended in 2017 for a further four-year period. Internally, teaching and research activities in the area of energy in ETH are coordinated by the Energy Science Center (ESC), which was extended for a further four years in 2017.

Basic research is at the heart of research activities at ETH Zurich, as well as of the key themes. The university awards some of its funding for these competitively. The competent research commission at ETH Zurich celebrated its 75th anniversary in 2017.

Representatives from ETH Zurich were also the recipients of prestigious awards in 2017. Prof. Nicola Spaldin received the "L'Oréal-UNESCO Award For Women in Science" and Prof. Ursula Keller was given the "Weizmann Women & Science Award". Prof. Nenad Ban was also awarded the "Ernst Jung Prize for Medicine", Europe's most highly-endowed medical award, and Prof. Antonio Lanzavecchia received the "Robert Koch Award". Prof. Michele Parrinello was the first scientist outside the US to receive the "Dreyfus Prize" in chemical sciences. ETH researchers were once again successful in their bids to secure coveted ERC grants in 2017 with eight ERC Advanced Grants, five ERC Consolidator Grants and three ERC Starting Grants (see p. 98). ■

EPFL

The Antarctic Circumnavigation Expedition (ACE) ended its three-month journey around the white continent in spring 2017. The scientific adventure which had been launched by the Swiss Polar Institute (SPI) brought together 150 researchers and 22 projects from a variety of areas, such as oceanography, climatology or biology. The data gathered is now analysed in order to gain a better understanding of the impact of global warming.

In the summer of 2017, the Bertarelli Foundation broadened its support for joint translational research projects to the central and peripheral nervous systems, which are carried out between the Biotech campus in Geneva and its partner institutions in the Lake Geneva region.

A comprehensive initiative to develop artificial muscles was launched at Microcity, EPFL's campus in Neuchâtel, at the end of 2017. Thanks to the support of the Werner Siemens Foundation, Prof. Yves Perriard's laboratory, collaborating with the university hospitals in Bern and Zurich, will be able to conduct research into a system which will support damaged hearts.

The operational implementation of the "Swiss Data Science Center" and of the "Advanced Manufacturing Center" also took place in 2017, assisted by the strategic focus areas of the ETH Domain.

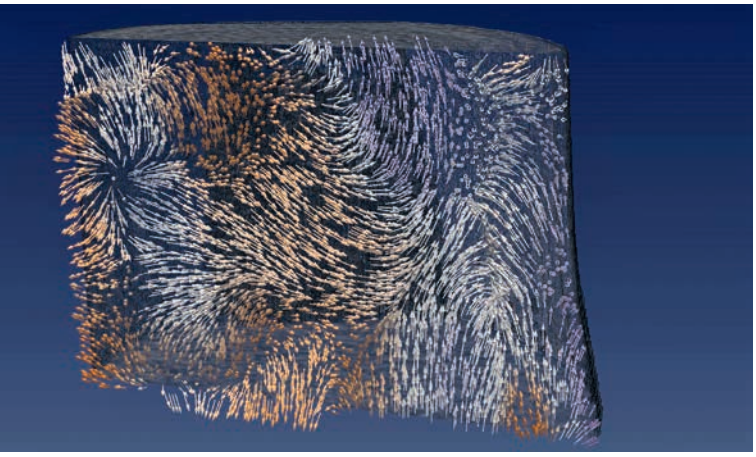
Switzerland emerged victorious in the international Solar Decathlon competition with a partnership involving the Fribourg School of Architecture and Engineering and the Geneva Haute Ecole d'art et de design and the University of Fribourg. This was due to the development of an innovative district centre which meets its energy needs exclusively from solar panels mounted on the façade.

EPFL has reinforced its presence further in Valais. In the second phase, the Energypolis campus in Sion received a new EPFL building to host the "Centre de Recherche sur les environnements alpins et extrêmes" (centre for leading-edge scientific and technological research in the field of alpine and extreme environments) and the competence centres for rehabilitation and health, as well as for green chemistry and energy of the future.

A number of professors were awarded prestigious prizes in recognition of their research work. Maryna Viazovska was awarded a New Horizons in Mathematics Prize in 2018 for her work on modular shapes and the sphere-packing problem in special dimensions. The catalysis specialist Xile Hu was awarded the national Prize in 2017 for his ground-breaking research in the area of the generation of solar fuel, as well as in the synthesis of molecules with a high degree of added value. The Global Energy Prize ultimately went to Michael Grätzel for the development of solar cells of the same name.

And last but not least, EPFL placed particular attention on opening its doors to the general public. The campus in Lausanne welcomed numerous visitors and specialists in 2017 on the occasion of the EPFL Drone Days, Swiss Robotics Industry Day and EPFL Open Access Week. ■

Core drilling on the Mertz Glacier as part of the SubICE project. The project, which was led by Liz Thomas, has set out to "read" the climate of the Antarctic from different ice samples.
(Photo: Noé Sardet/Parafilms/EPFL)



First ever 3-D visualisation of internal magnetic structures. *(Photo: PSI)*

PSI

While the installation of two experimentation stations was completed on the PSI's latest large-scale research system, the SwissFEL X-ray free-electron laser, and the first pilot experiments were conducted in autumn 2017, user operations at the other large-scale research installations ran at full speed, as usual. More than 2,500 scientists from Swiss and foreign universities, research institutions and industry visited the PSI in 2017 to conduct experiments on the Swiss Light Source (SLS), the Swiss Spallation Neutron Source (SINQ) and the Swiss Mμon Source (SμS).

The first calls for projects were conducted in 2017 in the strategic focus areas defined for 2017–2020, i.e. Data Science, Personalized Health and Related Technologies, and Advanced Manufacturing. The PSI has been successfully involved in all these call processes; and work is already under way in some of the projects approved by the Swiss Data Science Center and in the area of Advanced Manufacturing. In order to consolidate these key research themes at the PSI in the long term and to step up networking with the universities, four of the call processes currently being done in association with various universities are taking place in the fields of Data Science (modelling), Advanced Manufacturing (nanophotonics) and Energy Research. Within the scope of the digitisation initiative which has been launched initially within the PSI, the particular aim is to identify synergies between Data Science, Advanced Manufacturing and Digitisation in the area of large-scale research installations and to involve industrial partners as much as possible.

The PSI can exhibit outcomes of scientific significance in a variety of research areas. Collaborating with researchers from ETH Zurich and the University of Glasgow, the three-dimensional orientation of the magnetisation inside a material can be examined and visualised non-destructively for the first time. The new method can be used to create better, tailor-made magnets, e.g. for motors and data storage.

An important milestone has also been reached in application-oriented energy research: the power-to-gas technology developed at the PSI for direct methanisation for the storage of renewable energy has successfully passed its first practical trial. The technical feasibility was demonstrated on the scale of a commercial biogas plant, and the biogas yield was increased by 60% in a 1,000 hour test at the Werdhölzli fermentation and sewage treatment plant. ■

WSL

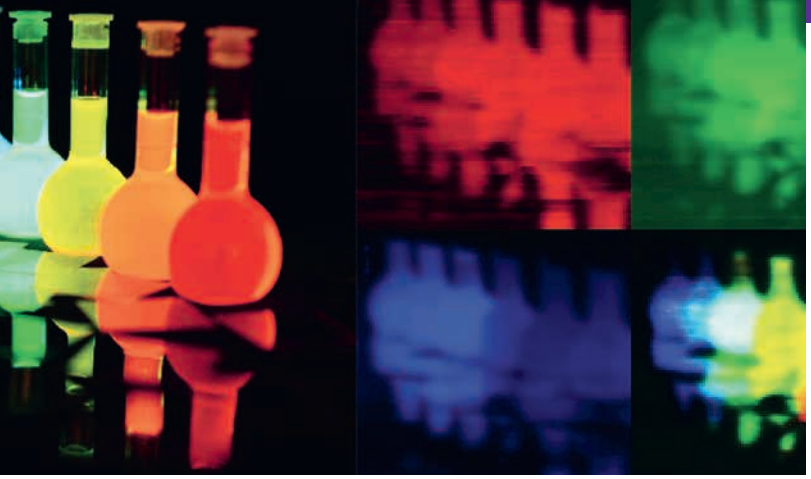
The WSL conducts research into forests, landscape, biodiversity and natural hazards, as well as snow and ice. These research topics, which may appear unconnected at first glance, all indicate that the effects of climate change play a key role in many issues. How do symbiotic communities like forests or the alpine snow cover respond to higher temperatures and a changing precipitation regime? Can woodland still supply wood, protect against natural hazards and serve as habitat? How should humans act and respond? The work conducted by WSL on these issues has gained recognition within the scientific community: Prof. Francesca Pellicciotti was awarded an ERC Consolidator Grant for five years for her research into loss of mass in Himalayan glaciers. She chose WSL as her host institution. In fact, this is the second such grant awarded to WSL (Anna Hersperger received a Consolidator Grant from the SNSF's temporary backup schemes as Switzerland had not been approved for ERC grants).

The Energy Change Impact research programme – operated jointly with Eawag and funded with 1.5m CHF under the action plan "coordinated energy research Switzerland" – will be continued with funding from WSL's basic contribution. Following an internal call process, WSL will be financing five new projects. Thanks to the "Knowledge transfer in major energy programmes" working group, which was initiated by WSL, the findings are cascading down into society with particular efficiency.

"Scientific integrity" was also an issue for WSL in 2017, as it had been in previous years. New employees with scientific duties are advised by their line managers and mentors about the rules and importance of integrity, which can be reread at any time in a brochure. There is an internal point of contact for questions and issues requiring clarification. Following a retirement, there is a new person in this post. There have not been any major problems or infringements so far. There will once again be a major internal event under discussion in 2018.

Rising temperatures are compelling many species of plants in mountain regions to migrate up the slopes. This could pose a danger to stone pine forests as habitats. WSL and Senckenberg scientists have shown that the spotted nutcracker prefers to finds its food – pine nuts from which young pine trees later shoot – close to today's tree line. ■

Endangered stone pine forest habitat. (*Photo: Sabine Brodbeck/WSL*)



The image sensor enables the original to be imaged with faithful colouring. *(Left in the photo; photo: Empa)*

Empa

From mobile phones and electric cars to storage batteries for apartment blocks; lithium-ion batteries have conquered the world. However, there are also disadvantages to the popular power storage systems, such as the increasingly limited availability of raw materials or risk that they may catch fire. Therefore, Empa researchers are working on alternative ideas for the storage of energy. They involve low-cost large batteries for the long-term storage of solar power, such as aluminium batteries with a graphite cathode, batteries with solid electrolytes or water-based electrolytes that cannot ignite, and the long-established molten sodium battery whose performance the researchers are aiming to improve considerably.

In the area of sustainable mobility, Empa researchers developed a new open-pored catalytic converter in 2017 with a special coating, which can be heated before the car engine is started through the use of microwaves – getting around the problem of cold starts. As a cold catalytic converter is much less efficient, over 90% of all the pollutants occur in the first minute after a petrol engine undergoes a cold start. In other words: If the vehicle continues on without stopping, the first 500 metres travelled pollute the air in extreme cases just as much as the next 500 metres. The lattice structure made up of thin ceramic braces, produced by means of stereolithography – a form of 3-D printing comprising liquids and UV light – heats up to 250 degrees within 10 seconds.

Further innovation partnerships have been set in motion, with Migros among others, for the "move" mobility demonstrator. Sustainable solutions for the transport of goods are being developed jointly with the aim of developing new drive concepts with lower C02 emissions, as well as a sustainable fleet strategy. Moreover, a 30 kWp pilot plant made of flexible, high-performance thin-film solar modules from Flisom, an Empa and ETH Zurich spin-off, went into operation on the back of move. Solar energy can be used to charge electric vehicles and to produce hydrogen for fuel cell vehicles in an environmentally friendly manner.

Empa researchers achieved a world-first in nano research: manufacturing a field-effect transistor from graphene nanoribbons. The tiny, regular structures made from carbon atoms are only a nanometer, or nine atoms, in width and up to 50 nanometers in length. The nanoribbons allow researchers to "grow" from specific precursor, molecules on a gold surface, resulting in graphene with identical molecular structures and with the same electronic properties, which is a prerequisite for future nanoelectronics.

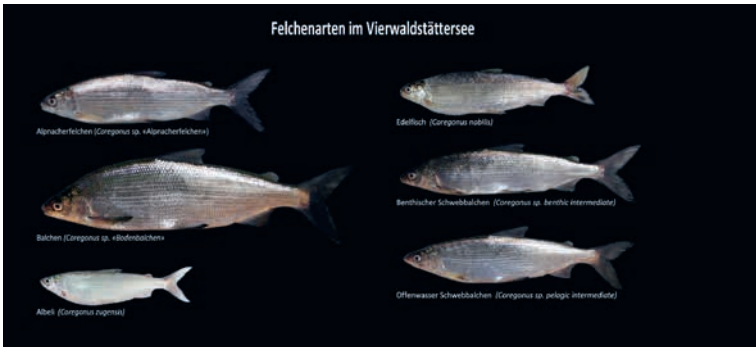
Innovative, yet cost-effective, colour sensors measuring just one pixel in size were produced by researchers from Empa and ETH Zurich using semiconducting perovskite layers. Special aspect of this: The sensors for Red, Blue and Green are layered on top of one another instead of being arranged in a mosaic pattern as has been the case up to now. It enables sensors to be created with unprecedented levels of resolution and sensitivity to light. ■

Eawag

Eawag is conducting research into how aquatic ecosystems change with the addition of nutrients in the first project being undertaken in the 36 new open-air experimental ponds. The ponds are filled with mains water and with some water drawn from the Greifensee lake, which already contains algae. Combinations of mussels and water-based plants from bodies of water nearby have been added to some ponds. The researchers are studying the effect that these organisms have on algae growth once phosphorous and nitrogen have been added. They are looking at the resilience of ecosystems after problems. Eawag is aiming to use it to gather experience for further pond projects on biodiversity and on adjustments to reflect environmental changes.

In engineering, Eawag is additionally involved in the NEST modular experimental building with its Water Hub, exploring new opportunities for water supply, material recycling and new sanitation systems. The requisite facilities were expanded further in 2017. Together with ETH Zurich, Eawag also launched an urban-hydrological field laboratory in which it uses sensor networks, state-of-the-art measuring instruments and innovative remote data transmission to record the processes in an urban water catchment area in terms of space and time (see also p. 15).

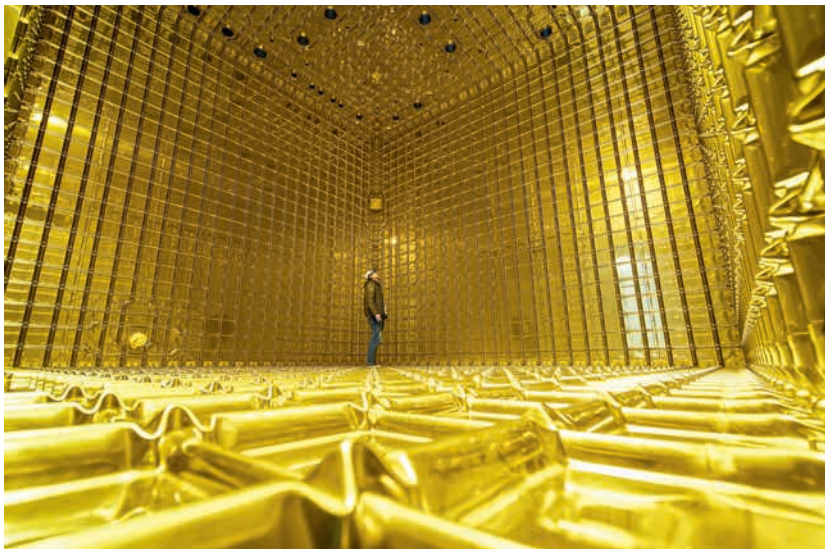
Humans are influencing evolutionary processes in the environment. In the case of whitefish in the Swiss lakes, the effect of this is that few so-called generalists displace the specially adapted species. Researchers led by Prof. Ole Seehausen are studying today's catch yields in relation to the remaining functional diversity. In lakes such as Lake Thun or Lake Lucerne, which have not experienced heavy eutrophication and still have a relatively diverse whitefish population, anglers catch more whitefish biomass per unit of phosphate than they do in Lake Zug or in Lake Geneva. The conclusion drawn by the researchers is that nutrient reserves are being used more efficiently in those lakes. Their study supports the theory that the fish make more efficient use of nutrient resources if there is great diversity of stock. ■



Recently identified: White fish diversity in Lake Lucerne. *(Photo: Eawag)*

3

"The ETH Domain is involved in the operation and development of research infrastructure."



Inside protoDUNE: researchers are seeking to discover neutrinos in the "golden cage". *(Photo: CERN)*

The ETH Board's perspective

The development and operation of the research infrastructures of the ETH Domain, as well as the involvement in international research infrastructures proved to be extremely satisfactory in 2017.

The first pilot experiments have been carried out on the ARAMIS beamline of the SwissFEL X-ray free electron laser on the PSI. It will be available for user operation from 2018. Parallel to that, work got under way on the construction of the second ATHOS beamline, which will increase capacity and facilitate a wider range of experiments. Around 2,500 scientists from Switzerland and abroad conducted experiments on the Swiss Light Source (SLS), the Swiss Spallation Neutron Source (SINQ) and the Swiss Muon Source (SμS).

The first three modular, occupied residential and office units went into operation in the NEST research and innovation building at Empa and Eawag in 2017. These units facilitate the further development of new technologies, materials and systems under real conditions of use. NEST extended its network to partners from industry, universities and the public sector, and has become a magnet for the general public.

In 2017, the Blue Brain Project at EPFL started, among other things, to develop models of other regions of the brain, reaching important milestones along the path to the digital reconstruction and simulation of the brain. Research results have appeared in renowned publications.

The "Piz Daint" supercomputer at the CSCS at ETH Zurich was ranked as the world's third most powerful computer in 2017. The scientific user lab offers researchers the very best possibilities for computing and data-intensive simulations and contributed towards significant findings.

Important modernisations are under way to the accelerator complex and detectors at CERN. The ETH Domain will contribute significantly to this through the upgrade to the CMS detector, headed by ETH Zurich.

ETH Zurich

Most high-powered computer outside Asia

The Swiss National Super Computing Centre (CSCS), as a sustainable scientific user lab and service facility, operates the "Piz Daint" supercomputer, among others. Researchers used it once again in 2017 to aid them in their search for answers to fundamental questions, such as in climate science, quantum physics or neuroscience.

The CSCS at ETH Zurich, which is operated as a scientific user lab, currently manages over 700 users with around 110 projects. In addition to its flagship supercomputer "Piz Daint" for the user lab, the systems operated by the CSCS include the weather computer of the Swiss Met Office, MeteoSchweiz, one of the clusters for the analysis of data from the Large Hadron Collider (LHC), as well as a computer for the Blue Brain Project. Software and application services are available. Users from research and industry may apply for computing time. A pay-to-go system has recently been introduced which enables smaller projects to purchase computing time quickly and easily.

Boasting a top performance capacity of over 25 petaflops, "Piz Daint" rose to the ranking of third most high-powered computer in the world. In addition to the upgrade to the very latest technologies at the end of 2016, the cleverly devised system, along with the many years of collaboration between CSCS, hardware producers and researchers from a variety of backgrounds enabled this successful development to take place. The cooperation was launched in 2009 as part of the national High Performance Computing and Networking strategy (HPCN strategy).

The latest research results also demonstrated the versatile use of the "Piz Daint" universal computer platform in 2017. In addition to conventional simulations, it is also especially suitable for highly complex and time-intensive simulations, as well as for data analysis. For example, climate researchers were able to demonstrate with Piz Daint in 2017 that summer low-pressure areas, which

repeatedly cause flooding in Europe, draw their moisture from the Mediterranean. And thanks to Piz Daint's capacity to analyse large data volumes, neuromolecular biologists discovered correlations in the human genome which simplify the search for "memory molecules". In the medium term, that could lead to a better treatment of diseases which are associated with memory problems. In addition, Piz Daint receives realistic, high-precision simulations of air flow along the aerofoil chord of aircrafts. The results can be used for an optimal design of aerofoil chords, which in turn helps to save on fuel and reduce noise.

Switzerland is not only represented in the "Partnership for Advanced Scientific Computing in Europe" (PRACE) with Piz Daint as a member since 2017, it is also represented as a hosting member. This means that Swiss initiatives in high performance computing are more visible internationally and the country is more attractive as a centre of innovation. ■

Upgrade to CMS detectors at CERN

The Large Hadron Collider (LHC) and its detector systems at CERN in Geneva are used to research fundamental processes and to answer fundamental questions which shape our image of the universe. In particular, the LHC offers an important experimental platform in the quest to identify the physics outside the standard model, such as dark matter. An outstanding result achieved on the LHC is the evidence of the Higgs Boson ("Higgs particle") in 2012.

The programme for the years ahead consists of investigating the Higgs Boson in much more detail, and of continuing the search for other new particles and for the physics outside the standard model. In order to maintain the data rates required for the acquisition of high statistical data, the LHC will have to be expanded and upgraded in the coming years. The upgrades must be done in step with new experiments. Significant modernisations of the accelerator complex and of the detectors are planned during a scheduled operational interruption in 2022 and 2023. The expansion will open the path towards a highly intensive, multi-year exploration phase. The work on the detectors is long-term, and the most important investments will be made from 2017 to 2020.

The ETH Domain has contributed substantially towards the setup and towards the use of the Compact Muon Solenoid (CMS) experiments on the LHC and is also playing a lead role in the upgrade. ETH Zurich is responsible here for the expansion of the electromagnetic crystal calorimeter, while the upgrade to the silicon pixel detector will be performed jointly by the PSI and ETH Zurich. The work upgrading the two installations got under way in 2017 and is progressing on schedule.

The potential for major initial investments has been maximised with the upgrades to the detectors, and the ETH Domain's leading role in them has been extended to include components which are of critical importance to CERN. ■

EPFL

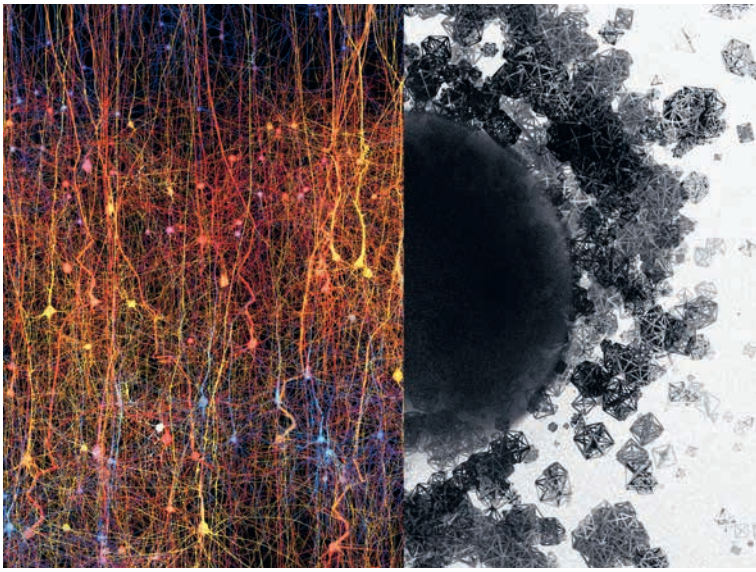
The Blue Brain Project, to better understand the multilevel structure of the brain

Blue Brain's goal is to build computer models and simulations of the brain and to use them to understand the brain. A roadmap defines project goals up to 2023, when the project plans its first model of a complete mouse brain. In the Blue Brain organisational structure, neuroscientists and engineers work in teams to achieve specific roadmap goals.

During 2017, Blue Brain started work on models of the somatosensory cortex, the hippocampus, and the thalamus, all based on methods developed for earlier models. Blue Brain's researchers published important papers in major journals including a major discovery derived from the application of algebraic topology to the Blue Brain microcircuit model.

The project also continued its work as the leader of the Human Brain Project subproject on brain simulation, and co-leader of the subproject on neurorobotics. Translational research initiatives included the creation of a startup, specialising in brain-inspired artificial intelligence and collaboration with EPFL neuroprosthetics labs. Finally, 2017 saw the launch of Blue Brain's MOOC "In silico neuroscience", which has already attracted more than 2,000 students.

Within the framework of Blue Brain, the so-called topology in neuroscience also attempts to facilitate the visual representation of processes and structures that in fact cannot be imaged.For example a universe of multi-dimensional structures and spaces. On the left side of the photo is a digital copy of a part of the neocortex, the most evolved part of the brain. On the right are shapes of different sizes and geometries in an attempt to represent structures ranging from 1D to 7D and beyond. The "black-hole" in the middle is used to symbolise a complex of multi-dimensional spaces, or cavities.



(Photo: Blue Brain Project)

Under the professorship of Friedhelm Hummel, a world-renowned expert in rehabilitation after strokes, EPFL and the Defitech Foundation have fostered the idea of using the technology as an aid for people with disabilities. (*Photo: Alain Herzog/EPFL)*

Swiss Plasma Center and ITER

The Swiss Plasma Center (SPC) continues to be involved in the ITER project on the development of a nuclear fusion reactor. This major international project has reached an important milestone with the completion of half of the project infrastructure. Various Swiss companies are involved in this project acting on behalf of the researchers at EPFL.

New professorships for EPFL Valais Wallis

The Sion campus of EPFL Valais Wallis created two new professorial posts during 2017: the "Gaznat" professorship for geo-energy, a post held by Prof. Kumar Varron Agrawal and which is a permanent part of the Institute for Chemical and Engineering Sciences. The new laboratory rounds off the research facility at the Sion site and and is especially given over to activities in the area of nanoporous separating membranes, as well as the MOFs (metal-organic frameworks) and graphene. The practical areas of applications relate, for instance, to gas separation (CO_2 problems) and to filtering out microparticles (water supply).

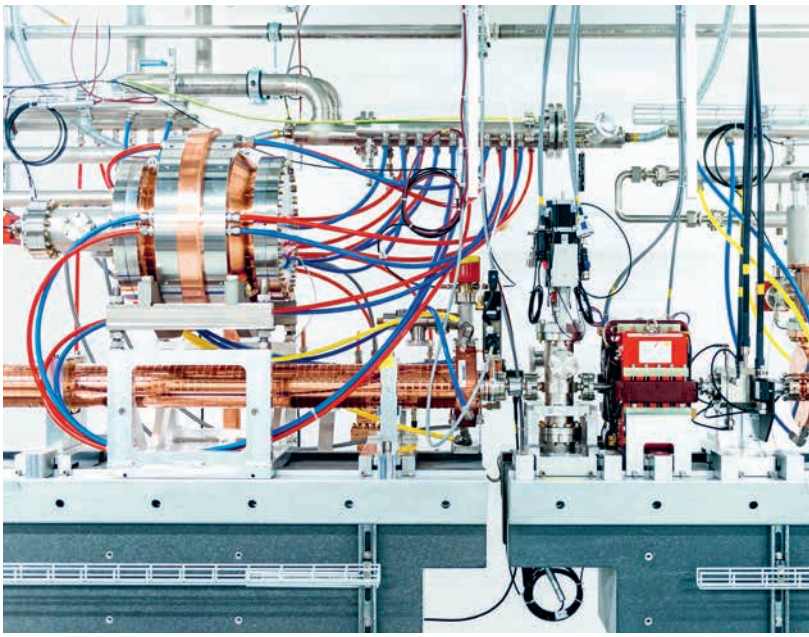
Secondly, Prof. Friedhelm Hummel has joined EPFL and taken over the leadership of the "Defitech" professorship for clinical neuro-engineering. The laboratory is sited in two locations: on the Biotech Campus in Geneva and at the Clinique romande de réadaptation SuvaCare (CRR) in Sion. Work is conducted there, for example, on researching the neurological mechanisms involved in post-stroke recovery or healthy ageing, as well as on neuroprostheses. ■

PSI

ATHOS: the second SwissFEL beamline takes shape

Only a year after the official opening of the PSI's latest large-scale research installation, the SwissFEL X-ray free electron laser, November 2017 saw the start of the pilot experiments, which had been awaited with excitement. This means that the ARAMIS beamline has officially gone into operation. From 2018, researchers from Switzerland and right around the world will be able to make use of two SwissFEL experimentation stations.

While preparations were still under way on the pilot experiments on the ARAMIS beamline, construction started on the second beamline, ATHOS, which will not only facilitate a higher capacity in available measuring time, but also a greater variety of experiments. Key here are the different properties of the x-ray light on the two beamlines. The very energy-rich ("hard") x-ray light, with a short wavelength, generated on the ARAMIS beamline are excellently suited to tracking where atoms move to, and how, during a rapid process. However, to have a closer understanding of what happens with atoms or molecules while they are forming a new chemical compound, "soft" x-ray light of lower energy is required, which will be generated on the ATHOS beamline. The special properties of the ATHOS beamline will, among other things, provide new insights into the workings of catalytic processes work, as well as of basic biochemical processes of life. In addition, soft x-ray light plays an important role in research into the electrical and magnetic properties of new materials for use in more high-capacity electronic components.



Accelerator module in the SwissFEL beam channel. *(Photo: Switzerland Global Enterprise)*

In the course of the year, important procurements were triggered for ATHOS, and the technical infrastructure such as cooling and power supply were installed. The construction of first accelerator components in the beam channel also got under way. The phased commissioning of ATHOS is scheduled to be done by 2019, with user operations commencing in autumn of the following year.

Parallel to the initial installation work, a three-day Photonics Spring Workshop was held at the PSI in April 2017. More than 75 external researchers held discussions with the scientists and engineers from the PSI about the needs of users for the ATHOS experimentation stations, as well as for the upgrade of the SLS ("SLS 2.0"), for which the design phase started in 2017. ■

Empa

NEST – a breeding ground for innovation

In the modular research building on the Empa campus in Dübendorf, researchers, companies and the public sector have the opportunity to validate and further develop new materials and technologies in a real environment. These innovations from the construction and energy sector are installed in units which are integrated into NEST as occupied residential and office-space modules.

Officially opened in mid-2016, the first occupants moved into NEST at the start of 2017. "Vision Wood" is a unit which is designed as shared accommodation, where different timber innovations, developed by Empa and ETH Zurich, are undergoing practical testing. In addition to "Vision Wood" and "Meet2Create", the third unit was opened in August 2017, a fitness & wellness facility which seeks to only guarantee operation powered by solar energy and by the physical efforts of the people working out. New wellness technologies will provide for a huge reduction in energy demands.

Two further units went into the construction phase in 2017: "DFAB HOUSE" is a three-storey unit, in which ETH researchers are seeking to apply several innovative, digital construction technologies from the laboratory in practice within the scope of the NCCR (National Centres of Competence in Research) on Digital Fabrication together with industrial partners – i.e. a house built with robots and 3-D printing processes. A further unit was integrated at the end of 2017 in the form of Urban Mining & Recycling, centred around the idea of resource cycles. The underlying theory is that all the resources required to create a building must be completely reusable, recyclable or compostable. "SolAce", a further unit developed at EPFL is also in the starting blocks already. The key theme of it is energy recovery through the façade.

The energy research platform "ehub", which uses NEST as vertical test accommodation, embarked upon its first research projects in 2017, aimed at optimising energy flows at accommodation level. The Water Hub, Eawag research facility within NEST, was extended in 2017 and is now capable of conditioning various wastewater flows on a larger scale.

In the past year, NEST has also enjoyed a high level of attention once again in specialist circles. In March, NEST received the "Umsicht – Regards – Sguardi 2017" award from the Swiss Engineering and Architects Association SIA. The NEST network has now grown to over 100 partners; around 12,000 people visited NEST in 2017 in the course of guided tours and events. ■

Sustainable wellness thanks to solar energy: external view of the "Solar Fitness & Wellness" unit.
(Photo: Reinhard Zimmermann/Empa)

4

"In order to reinforce Switzerland's innovative strength and competitiveness, the ETH Domain promotes collaboration and exchange with the economy and society."

The ETH spin-off Climeworks, which was founded in 2009, put its first commercial plant into operation in Hinwil, filtering carbon dioxide (CO_2) from the air. *(Photo: Julia Dunlop/Climeworks)*

The ETH Board's perspective

The institutions of the ETH Domain once again delivered a wide variety of services in knowledge and technology transfer (KTT) in 2017. Students and employees are widely encouraged to adopt an entrepreneurial mindset and act accordingly, and business enterprise is supported financially with suitable instruments, both proven and new. This includes coaching and consulting to assess the potential to realise a business idea commercially or to create a business plan. The success of these measures is borne out in the considerable number of newly established spin-offs (s. p. 92), in the award of important innovation prizes to spin-offs from the ETH Domain and in the substantial sums invested in them. The impressive quantity of patent applications and licensing agreements, as well as newly filed invention disclosures and cooperation agreements with industrial partners are testament to the vigorous KTT activities of the institutions. The total of the third-party funding procured from Innosuisse[1] and from industry is evidence of how attractive the ETH Domain is as an innovation partner. The institutions use events for industry, exchange platforms or specific news portals to provide information about current research activities and about possible new partnerships. The institutions also make important contributions at the sites of the Swiss innovation park, Switzerland Innovation. In the year under review, the media and public sector drew upon the expertise of the ETH Domain, in particular with regard to protection against natural hazards and of public assets such as landscape, water and woodland. An important role in KTT is played by academic continuing education programmes, practice-led courses and further education options which are becoming more inter-disciplinary and which particularly also incorporate aspects of social responsibility.

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

ETH Zurich

2,899 people graduated from ETH Zurich with a Master's degree or doctorate in 2017, giving industry, science and public administration the benefit of the knowledge and skills that they had acquired at the university. In addition to encouraging its students and employees to acquire professional skills, ETH Zurich also encourages them to think and act in a business-minded way. The success of these measures is borne out, among other things, by the fact that ETH Zurich has produced over 20 spin offs (25) for the 11th year in a row. The success of the ETH spin-offs is also reflected in the substantial investments: the published investments in ETH spin-offs in 2017 alone was over CHF 120m. GetYourGuide secured the largest investment with CHF 75m. In addition, various ETH spin-offs were bought up in full or in part in the year under review, including Adaptricity, Dacuda and Kapanu. Most companies will remain in existence and may continue to grow in Switzerland. It has enabled major international corporations, including Apple, Microsoft, Facebook, GoPro, Qualcomm or ESRI, to set up in Zurich either with new or additional locations. These companies are set to benefit from the outstanding graduates being produced by ETH Zurich. Google announced in 2017 that it was increasing its workforce in Zurich from the current figure of around 2,000 to up to 5,000 employees.

191 inventions and software were registered in 2017, along with 84 patent applications, and 114 licence and technology-transfer agreements were concluded.

ETH Zurich gives companies of any size a direct insight into its research and keeps them informed in the "ETH News for Industry", which was launched in 2017, about ongoing research, possible partnerships, licences and forthcoming events. The news portal which was opened at the end of August already has nearly 900 subscribers to the newsletter. Industry Day 2017 set a new attendance record, attracting 600 visitors from commerce and industry.

These exchange platforms are of pivotal importance for the university, although complex problems are frequently solved at the interface between research and industry nowadays.

ETH Zurich embarked upon more than 300 new cooperations with companies in Switzerland and abroad in 2017. They include more than 42 Innosuisse-backed research and development projects with Swiss companies, the majority of them SMEs. Framework research agreements have been concluded or renewed with Migros Genossenschaftsbund, Novartis and The Walt Disney Company. The strategic alliance between ETH Zurich and inspire AG, the Competence Centre for technology transfer to the mechanical and electrical engineering and metal industries, was renewed again in 2017. Along with 50 partners, ETH Zurich brought the "ESA business incubation centre Switzerland" to Zurich in 2016, and it got off to a very successful start in 2017. 10 start-ups from all across the country are already benefiting from support in implementing aerospace technologies in innovations.

A central pillar of knowledge transfer is the extensive academic continuous education programmes at ETH Zurich. Two Master of Advanced Studies (MAS) courses were added in 2017: MAS in Mediation and Peace Processes, and MAS in Science, Technology and Policy. In addition, ETH Zurich has now pooled its continuous training programmes and courses in four clusters: Public Policy and Governance; Technology, Management and Innovation; Environment, Infrastructure and Architecture; as well as Health, Life and Natural Science. This move is intended to nurture collaboration between departments and programmes, as well as to improve the transparency of the courses on offer. ■

EPFL

The Vice President for Innovation (VPI) at EPFL has brought new programmes into being in order to promote entrepreneurship among students and social entrepreneurial spirit, along with new mechanisms for underpinning cooperation with industry.

A total of 15 new start-ups were founded in 2017, mainly in the areas of electronics, IT, medical technology and biotechnology, as well as energy. Capital procurement for these EPFL start-ups amounted to CHF 112m, as well as CHF 30m for the start-ups in the EPFL innovation park, thanks to companies such as Aleva Neurotherapeutics and Anokion. Another example is KB Medical, which was taken over by Globus Medical, a leading manufacturer of musculo-skeletal solutions.

Six EPFL spin-offs, which make the top ten of Switzerland's TOP 100 start-ups, are testament to the quality of the companies. While 10 support contributions were awarded in the established Innogrants programme, consistent with previous years, the start-up unit of the VPI has created a new tool: X-Grants, providing financial support of around CHF 10,000 to Bachelor's and Master's students for the development of their business enterprise projects. Even though this programme was only launched in October 2017, 10 projects received backing in 2017.

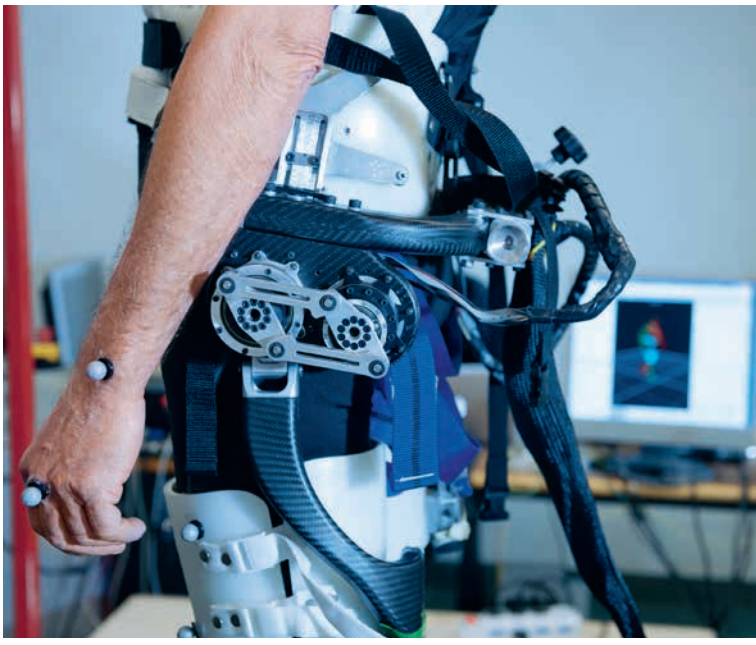
The total number of new licensing agreements with industry was 55, whereas 95 new patents (priority applications) were submitted. The support for industrial research projects amounted to CHF 42m.

The new SME unit of the VPI is preparing the inaugural staging of a major event on the EPFL campus in 2018, intended to support SMEs in their digital transformation. The Programme Alliance is continuing its task as part of the innovation system for western Switzerland, in particular through setting up cooperation projects between EPFL and SMEs which receive funding from Innosuisse. In the past year, Innosuisse backed a total of 45 EPFL projects to the tune of CHF 14.9m.

The EPFL innovation park achieved occupancy of 98% in 2017. Its new occupants included Romande Energie, which is developing a competence centre for data usage in the energy sector, and Eutelsat, a joint venture with ViaSat. Two other large companies signed contracts to move into the EPFL innovation park in early 2018. VPI also sought to improve the integration of the innovation park on the EPFL campus by launching new networking events.

The VPI Large Companies unit formed two teams to strengthen their activities for business development and for strategic partnerships (including those of the innovation park). In particular, a framework agreement was concluded with ABB.

In addition, the VPI launched a Social Impact Initiative towards the end of 2017 to link innovation and technology with social issues. The initiative is planning to set up the Yunus Social Business Center at EPFL within the scope of the partnership with the Nobel peace laureate and microcredit inventor, Muhammad Yunus. ■



Together with Scuola Sant'Anna, a team headed by EPFL professor Silvestro Micera has developed a unique exoskeleton which stops elderly people from falling over.
(Photo: Hillary Adrienne Sanctuary/EPFL)

GratXray wins the Swiss Technology Award. *(Photo: PARK INNOVAARE)*

PSI

The close cooperation and exchange with industry and SMEs, the promotion of entrepreneurship and the formation of spin-offs, as well as active involvement in the further implementation of PARK INNOVAARE as a centre of Swiss innovation are successful pillars in successful and sustainable knowledge and technology transfer at the PSI.

The PSI Founder Fellowship Programme for the promotion of business enterprise spirit among the next generation of scientists was launched in 2017. Young researchers and engineers from the PSI receive financial support, coaching and advice as well as further access to the PSI's research infrastructure for a period of 18 months. The purpose behind this is to highlight the potential for realising a business idea commercially which is based on results from research at the PSI, to develop an initial Proof of Concept, to draw up a business plan, and thus, to take the first steps towards becoming an entrepreneur. The first three PSI Founder Fellowships, which come with CHF 150,000, were awarded in 2017.

Nine companies have set up base in PARK INNOVAARE since 2015 (spin-offs and start-ups). The most recent arrival has been GratXray AG, a spin-off of the PSI and ETH Zurich, which was founded in July 2017. Using a computed tomography system which is the only one of kind in the world, GratXray is aiming to revolutionise imaging in breast cancer detection. The phase-contrast method used for this purpose produces extremely precise, detailed and high-contrast images of unprecedented quality and, at the same time, enables three-dimensional breast examinations to be performed without causing any undue discomfort. The method was originally developed for tomographic imaging on the SLS. That it is not only the founders of the company who are convinced about the innovative capability of this technology was evidenced impressively by the fact that GratXray received the Swiss Technology Award for 2017 in the "Inventors" category. In addition to GratXray, the spin-off Araris AG, which is in the process of being formed, was also among the finalists for that important innovation award. Araris AG grew out of the PSI Founder Fellowship Programme and is using a technology developed at the PSI to develop cancer drugs more quickly and more reliably than before. ■

WSL

Woodland, landscape, biodiversity, natural hazards, as well as snow and ice are issues that are primarily confronting public sector bodies. Therefore, the main beneficiaries of knowledge transfer from WSL are federal agencies, cantonal and local authorities. In industry, the information is mainly aimed at engineering and planning offices. Up to now, there has only been anecdotal evidence of how these practitioners and users are most efficiently reached, among other things via books, websites, brochures or continuous education courses. In order to make more efficient and effective use of their resources and methods, WSL conducted a scientifically backed survey for the first time among key players from all areas of conservation throughout Switzerland. The findings reveal that knowledge gained from experience, such as from communication with colleagues or enquiries to experts, are of pivotal importance. The role that the various types of evidence-based knowledge, such as industry articles, books or specialist web portals play, vary depending on the field of activity, the part of the country or level of education of the respondents. The existing practice at WSL, which places great value on target group-specific publications – such as in trade journals or, very specifically, with its own series "Merkblatt für die Praxis" – is encouraged by the survey. These WSL products are generally widely read by conservationists. Researchers and communications experts from WSL will discuss the findings, exploring the question of whether the WSL adjustments need to be applied to the knowledge transfer portfolio.

The proximity of research and knowledge transfer, which is at times unexpectedly close, is demonstrated by the landslide at Piz Cengalo (GR) in August 2017. WSL was involved in an Arge Alp (Association of Alpine States) research project, which was examining the connection between permafrost and rock falls on the same mountain – from a purely scientific perspective. After the incident, its expertise on permafrost and landslides, mudslides, risk management and the conditions on the Cengalo is now much in demand, and not only in the media. A commission set up by by the canton to study the incident, draw conclusions, learn recommendations for the future and define further research needs, includes three experts from WSL (out of a total of 19).

Landslides cause great damage time and time again. As part of the National Research Programme on the "Sustainable use of soil as a resource" (NRP 68), WSL researchers have shown how adapted forest management and diversity in vegetation play a very significant and cost-effective part in protecting against landslides. ■

Protection against landslides thanks to adapted forest management and diversity in vegetation. *(Photo: WSL)*

Hard to distinguish from the original: A violin with a fingerboard made from "Swiss Ebony" instead of genuine ebony. *(Photo: Wilhelm Geigenbau AG, Suhr)*

Empa

With around 175 new contracts, including 25 new Innosuisse projects, Empa once again confirmed its committed cooperation with Swiss industry in 2017. In addition to those individual projects, it also entered into some strategic partnerships. Among others, with BASF (Switzerland), which, together with Empa and other institutions from the ETH Domain, is seeking to research and develop innovations in the long term in the fields of recycling management, digital production, surface structuring technologies, as well as materials and systems for the construction industry by setting up one of its innovation teams in the glatec Technology Centre on the Empa campus in Dübendorf.

Empa's patent portfolio currently comprises nearly 100 patents. In 2017, it registered 14 new patents, either alone or in partnership with industry, and 13 new licensing and exploitation contracts were signed.

In addition to the cooperation with established companies, Empa actively promotes the founding of start-ups. "Swiss Wood Solutions", a spin-off which was founded in 2017, has been specialising in alternatives to tropical woods, e. g. for making instruments. Their product "Swiss Ebony" took first place in an audio test with professional musicians and music students, together with real ebony. In future, Swiss Ebony could also be used for lifestyle products such as watch components, snooker cues and knife handles. The founder Oliver Kläusler was also one of the two Swiss finalists in the "Falling Walls Lab" and had the opportunity to pitch his idea to a major international audience in Berlin.

Another start-up was the spin-off "Nahtlos" (seamless). It offers product development using an innovative technique developed at Empa that welds the synthetic fibre fabric, making the "seam" airtight and waterproof. The Empa-backed business incubators nurtured a total of 49 start-ups in 2017.

The Technology Creativity Centre (now under the name of Smartfeld) was founded in the Startfeld innovation centre in St. Gallen, which is closely associated with Empa and which is managed by Empa, in 2017. It plays an important part in knowledge transfer, and its first "Smart Textiles" programme is especially aimed at schoolchildren. ■

Eawag

At its annual Info Day in September, Eawag explored an issue which was under much discussion in the year under review, "Agriculture and Water" (see also p. 5). Tying in with that, experts explored the conflicts that exist at the interface between groundwater and farming in smaller groups within the scope of a practice-led Eawag course (PEAK) organised in conjunction with the University of Neuchâtel. Other PEAK courses on topical themes were: Heating and cooling with lakes and rivers; Synergies between hydraulic engineering and ecology; and Fundamentals of the strategic revitalisation planning for lakes.

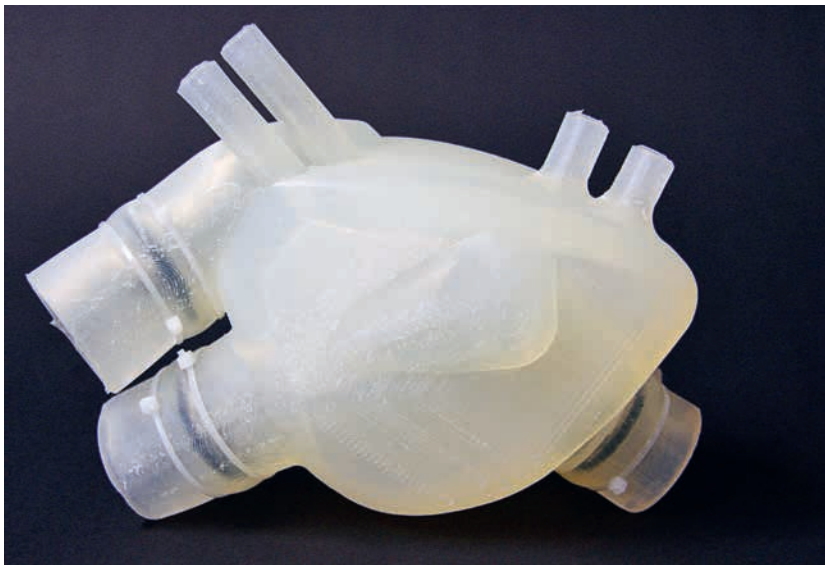
Eawag is having its invention for the addition of nutrients to soaps patented. Such admixtures enable the reactions to take place optimally in downstream wastewater treatment processes without having to add the substances there.

Eawag is offering alternatives to animal-testing in ecotoxicology with the new spin-off aQuaTox-Solutions GmbH. A further spin-off onCyt Microbiology AG enables quick, automated microbial monitoring in drinking water.

Eawag researchers have developed a mobile mass spectrometer. The "Mini-Ruedi" allows gas analyses, which used to take months, to be performed there and then in the field in a short space of time. For instance, it only took an Eawag team two weeks to conduct a complete gas analysis of groundwater in Australia. It is estimated that it would have taken six years to do this with conventional techniques in the lab. Nonetheless, measuring accuracy is guaranteed: Deviations are a maximum of 1 to 3%. In addition, the 13 kg device is energy-efficient and requires barely any maintenance. It is currently able to quantify helium, argon, krypton, nitrogen, oxygen, carbon dioxide and methane – more gases are being added continuously. The invention has now led to a spin-off with the name of Gasometrix. Its first customers include the University of Oxford. ■

Mini-Ruedi in use around the world – in Australia, Oman and on Lake Soppensee in Lucerne. *(Photo: Eawag)*

5 *"The ETH Domain is actively involved in shaping the Swiss university sector."*



ETH researchers from the functional material engineering group have developed a silicone heart, which pumps in a way that is very akin to a human heart. (*Photo: Zurich Heart)*

The ETH Board's perspective

The ETH Domain maintains a large number of national cooperation arrangements in teaching and research, whether it be within the ETH Domain or with cantonal universities, universities of applied science and other national entities. They concern both the strategic focus areas of the ETH Domain and the strategic priorities of the institutions, national research initiatives and standalone projects.

A number of interdisciplinary cooperation initiatives were set up and rolled out in 2017, in particular concerning the activities of the institutions of the ETH Domain in the field of medicine and medical devices in cooperation with cantonal universities and hospitals, as well as research platforms in the area of energy research. In addition, there is a series of national cooperation arrangements in which the institutions of the ETH Domain play a coordinating role, such as in seven of the eight Swiss Competence Centers for Energy Research (SCCERs).

Cooperation has also been stepped up in teaching. ETH Zurich is running nine Master's degree courses jointly with other universities, and has also launched a new Bachelor's degree course in medicine. EPFL has consolidated the existing programme of links for a medicine degree course. The cooperation between the research institutes and the two Federal Institutes of Technology, as well as with cantonal universities and universities of applied science has also been consolidated with joint professorships

EPFL has ultimately renewed its strategic alliances with CSEM, Idiap and SwissTPH, just as ETH Zurich has done with IRB and inspire AG.

ETH Zurich

ETH Zurich is drawing upon its cooperation with cantonal universities and hospitals in the development of its strategic focus on medicine. The aim is to complement the existing skills to optimum effect. ETH Zurich is involved in the Swiss Personalized Health Network (SPHN) and heads the strategic focus area on Personalized Health and Related Technologies (PHRT) at the ETH Domain. Both programmes are seeking to combine the clinical expertise of university hospitals with the technological and scientific expertise of the universities and institutions of the ETH Domain to achieve improvements in personalised diagnostics and therapy on the basis of patient data. ETH Zurich, the University of Zurich and the city's university hospitals took a decision in 2017 to establish a "Center for Precision Medicine Research". In Tessin, ETH Zurich will work more closely with the Cardiocentro Lugano in future. An agreement was duly signed in 2017. The strategic alliance with the Instituto di Ricerca in Biomedicina (IRB) at the USI in Bellinzona was extended for the period from 2017 to 2020. This cooperation was consolidated significantly with a donation of 6m CHF from the Helmut Horten Foundation.

The Department of Biosystems Science and Engineering (D-BSSE) in Basel celebrated its tenth anniversary in 2017. The impulse investments in Basel led to other very effective collaborations between the University of Basel, Basel University Hospital Basel and ETH Zurich in 2017.

With D-BSSE, ETH Zurich embedded system biology within its institutions on a lasting basis, safeguarding the long-term effectiveness of the investments of the Swiss initiative for the promotion of system biology, SystemsX.ch. The Swiss Confederation has thereby supported 249 interdisciplinary research projects and over 2,000 researchers in 15 universities and research institutions with 220m CHF over a period of nine years. They include 87 interdisciplinary doctoral projects and 32 transition postdoc fellowships to support the upcoming young scientists. So far, 1,420 publications have appeared within the scope of SystemsX.ch, 40% of them in

leading magazines. The initiative has been led by ETH Zurich. The final projects will be completed at the end of 2018.

ETH Zurich also has a considerable involvement in the strategic focus areas of the ETH Domain. It worked with EPFL on the development of the Swiss Data Science Center, which was opened in 2017. It leads three of the total of seven Swiss Competence Centers for Energy Research (SCCERs). In addition, the first projects of the focus area on Advanced Manufacturing, involving researchers from ETH Zurich, were launched in 2017.

ETH Zurich, the university and the canton of Zurich opened the Agrovet-Strickhof in Lindau in September 2017. These state-of-the-art facilities enable researchers to explore the added value, from the production of feed, to the livestock and on to the food. In addition to the main location in Lindau, the Agrovet-Strickhof cooperation also takes in the locations of Früebüel (ZG) and the alpine grassland at Alp Weissenstein (GR), enabling projects to be carried out at different altitudes.

Partnerships are also gaining importance in terms of training. ETH Zurich is running nine Master's programmes as joint degrees with other universities, two of which are with international partners. The University of Basel was also brought on board as a partner in 2017 for the Master's degree course in "Computational Biology and Bioinformatics" run by the University of Zurich and ETH Zurich. By siting the course in the Department for Biosystems Science and Engineering in Basel, it will also benefit from its close proximity to the pharmaceuticals industry.

To promote STEM subjects at key stage 3 and 4, ETH Zurich has been offering a course in "Teaching Mathematics" in addition to the course of "Teaching Science" in association with the Teacher Training College and University of Zurich since 2017. These graduates will be providing training for the next generation of teachers in STEM subjects. ■

EPFL

EPFL also continued its cooperation with the universities of Lausanne (UNIL) and Geneva (UNIGE) in 2017, which is primarily geared towards the "Passerelle" or "Links" programme, which the three universities introduced in 2012. The link with the Faculty of Medicine at UNIL allows half a dozen graduates with a Bachelor's degree in Life Sciences from EPFL to transfer over to the Master's course at the Faculty of Medicine (fourth year of the Medicine degree course) after completing an additional year which is focused on medicine. The students are chosen based on their application files at the end of the Bachelor's degree. This programme will be rolled out within the scope of the special programme on Human Medicine. 10 students will be admitted via the link with the Faculty of Medicine at UNIL in 2017 and 2018, and this will be 20 from 2019. It will be available to eight students via the link with the Faculty of Medicine at UNIGE from 2018.

EPFL is consolidating the national strategy for personalised medicine with the genomic platform which EPFL has built with its partners in Geneva, UNIGE and the University Hospitals (HUG). This platform, which has four sequencing devices of the latest generation, can currently analyse 200 complete human genomes every week. The platform is located in the Biotech campus in Geneva and is at the disposal of the entire academic community in Switzerland, as well as the clinics.

EPFL is also an active partner in the "Swiss Personalised Health Network". Firstly, via the Health 2030 initiative, which comprises four universities (EPFL, UNIGE, UNIL, UniBE) and three university hospitals (CHUV, HUG, Inselspital). And secondly, via the strategic focus area in Personalized Health and Related Technologies (PHRT), which is geared towards placing the ETH Domain, and Switzerland, at the forefront of this medical revolution. EPFL is pursuing nine projects within the PHRT focus area, and its partners include ETH Zurich, CHUV and UNIL.

EPFL is also involved in the further development of supercomputing skills in Switzerland. It has a supercomputer for intensive simulations as part of the Blue Brain Project through a partnership with the Swiss National Supercomputing Centre (CSCS) in Lugano.

The Swiss Polar Institute (SPI), which was established upon the initiative of EPFL and under the auspices of the federal government, launches interdisciplinary projects and promotes synergies between Polar researchers in Switzerland. In addition to EPFL, the researchers are also based in ETH Zurich, WSL and the University of Bern (UniBE).

The Swiss Data Science Center (SDSC), which grew out of a data science initiative by the ETH Board, is now fully up and running and currently has a staff of around 20 people. There were 140 guests in attendance from the world of academia at the official opening in February. The event was widely reported throughout Switzerland (over 50 print and online articles, as well as various television features). The SDSC is aiming to accelerate the spread of data science and machine learning both within the academic disciplines of the ETH Domain and throughout the scientific community and the industrial sector. In this context, 74 teams of researchers submitted a project proposal in the first call. Eight projects from all the institutions of the ETH Domain started in the autumn, and six more will start in spring 2018.

A day organised on the theme of preventive maintenance in November met with a positive response from Swiss industrial companies. Almost 45 companies accepted the invitation to attend the SDSC. ■

The new SDSC is a guarantee that Switzerland is developing the skills required in the field of data science.
(Photo: Swiss Data Science Center)

Emiliana Fabbri and Thomas Schmidt in a PSI laboratory, where they have investigated the performance capability of the newly developed catalytic converter for electrolysers. *(Photo: Mahir Dzambegovic/PSI)*

PSI

A total of 48 professorial posts were filled with scientists from the PSI in 2017 at ETH Zurich, EPFL and at Swiss and foreign universities, as well as at universities of applied science. In order to further underpin networking with Swiss universities and to strengthen developments in new key research themes at the PSI sustainably, there were calls for a further three professorships in the areas of Non Linear Optics (University of Bern), Modelling (ETH Zurich) and Energy System Analyses (ETH Zurich) in 2017. Each of these professorships is linked to the leadership of a research laboratory at the PSI, forming a solid basis for cross-institutional research cooperation.

The PSI performs national coordination duties in the area of energy research, among others. In its capacity as a leading house for the two SCCERs for Biomass and Storage, and as the operator of the ESI platform, the PSI collaborates closely with research partners within and outside the ETH Domain and intensifies the cooperation with industrial companies. Similarly, the geographical proximity to and integration into the strategic further development of the PARK INNOVAARE for the PSI enable its user-led research activities to be well embedded regionally and nationally. The PSI attaches particular importance here to forging collaborations which are as close as possible with Swiss universities of applied science because the PSI can benefit from the long-standing experience and partnerships that exist between these universities and industrial companies.

One successful example of how different partners were able to use their complementary skills profitably to find a solution to a scientific problem is that of an innovative catalytic converter material which was developed by Empa and PSI as part of a joint project. The material, which is synthesised in the form of nanoparticles, accelerates the rate at which water molecules are split into hydrogen and oxygen. This process, which is known as electrolysis, is an essential precondition for the possible storage of solar or wind energy in the form of energy-rich gases. In addition to the successful production of the material, its performance capability was also impressively demonstrated in a practical test. ■

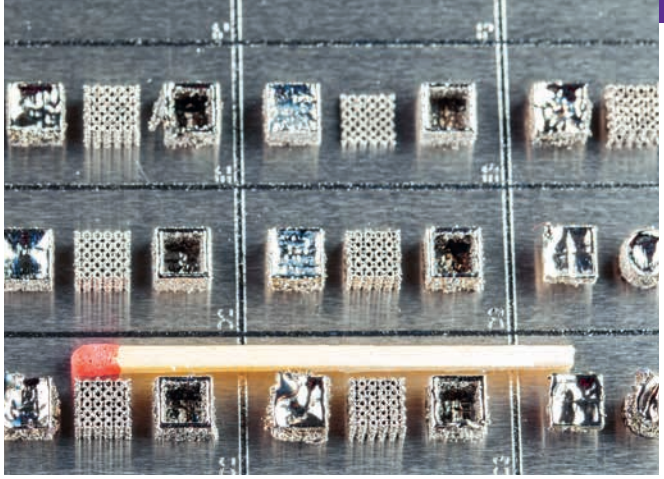
WSL

In the Pfyn Forest in mid-Valais, WSL has been irrigating 500 pine trees for 14 years, studying them and a control group of non-irrigated trees. The researchers are investigating what happens in the trees in the drought and why they even die under some circumstances. This long-term project, which is the only one of its kind in the world, can also be used as a research platform by other groups. It is an example of a test installation which has been brought into this woodland research network by WSL as part of its strategic SwissForestLab initiative. The researchers applied the network concept in a large-scale experiment in 2017. The crowns of several trees were completely wrapped in plastic sheeting. To enable photosynthesis to take place, the trees were then offered special carbon isotopes which rarely occur in nature. The researchers are able to track exactly how the tree distributes the sugar which is produced in the trunk and in the roots and perhaps how it even shares the sugar with neighbouring trees through symbiotic fungi. The labour-intensive experiment will be performed in collaboration with the University of Basel and ETH Zurich, as well as with foreign universities. The samples are analysed in the isotopic laboratory, which WSL has taken over from the PSI and thanks to which it has not only been able to consolidate its own research, but also cement its standing as an important partner in Swiss environmental research.

The fact that WSL has been collaborating closely with universities inside and outside the ETH Domain is also reflected in the posts of titular professor which are awarded to WSL employees. Irmi Seidl has been appointed as a titular professor at the University of Zurich, and Arthur Gessler has been appointed as a titular professor at ETH Zurich.

WSL also maintains a wide range of cooperation arrangements and partnerships outside the university environment. For example, it studied biodiversity in the vineyards of Tessin, in association with Agroscope and the cantonal natural history museum. The scientists have discovered 19 new species of invertebrates which are new to Switzerland. As a result, they were able to submit a new list of species to the FOEN, optimised for Tessin, which will serve as the basis for calculating direct payments to winegrowers. They ultimately published a book in Italian which outlined the findings from Swiss research projects. ■

SwissForestLab: the major project being led by Prof. Arthur Gessler in the Pfyn forest is to understand the impact of drought on trees. *(Photo: Gottardo Pestalozzi/WSL)*



Aluminium titanate specimens made on a 3-D printer. *(Photo: Beat Geyer/Empa)*

Empa

The area of Advanced/Additive Manufacturing plays a pivotal role for Empa, and this also proved to be the case last year. Firstly, the official opening of the newly established strategic focus area on Advanced Manufacturing in the ETH Domain, headed by Empa, took place in Bern on 13 November 2017 (see p. 5). Secondly, Empa consolidated its cooperation with the Canton of Bern and with Thun City Council in this area and in 3-D printing. A competence centre for innovative metallic tools and processes is being built at the Empa location in Thun. At the same time, Empa is set to broaden its cooperation in 3-D printing with the innovation park in Bienne and with sitem-insel AG in Bern.

Empa is also involved in various "Swiss Competence Centers for Energy Research" (SCCERs), including leading the SCCER on "Future Energy Efficient Buildings & Districts" (FEEB&D). Research will increasingly focus on systemic solutions, system integration and digitisation over the next four years. The collaboration with industry is close enough to enable the findings of the SCCERs to filter through to practical application as quickly as possible. For example, various technologies from the SCCER on FEEB&D have been taken on board by the e-can suisse cooperative, which has developed an innovative business model for hydro power by means of crowdfunding. The exchange of ideas with industrial partners was nurtured at various events throughout Switzerland during 2017, such as at the Energy+Building fair in St. Gallen in May or at CISBAT 2017 at EPFL in September with MIT and the University of Cambridge, where this very exchange of ideas was right at the heart of the "Science meets Industry" session.

The national research programme on "Resource Wood" (NRP 66) drew to a successful conclusion after five years in November. Empa had a considerable involvement in it with three projects and the formation of a spin-off company. Consequently, researchers from Empa and ETH Zurich have succeeded in altering the properties of wood through chemical and nanotechnological modifications. This makes wood considerably more stable – which had led to the formation of the "Swiss Wood Solutions" spin-off (see p. 57) – or even water-repellent. In order to protect wood more successfully as a building material for outdoor use from the effects of the weather and microorganisms, and more especially to protect the environment, Empa researchers have also developed innovative wood coatings made from nanofibrillated cellulose, which have been used for some time on the exterior façade of NEST on the Empa campus in Dübendorf. ■

Water kiosk in Lugala, Uganda. *(Photo: Eawag)*

Eawag

Alignment with national needs accounts for an important portion of Eawag's work. Looking ahead to the Energy Change in Switzerland, it concerned itself in 2017 with collaborating with partners from the Swiss Competence Centers for Energy Research (SCCER), in particular on themes relating to the use of hydro power. The researchers from Eawag explored the ecological aspects primarily.

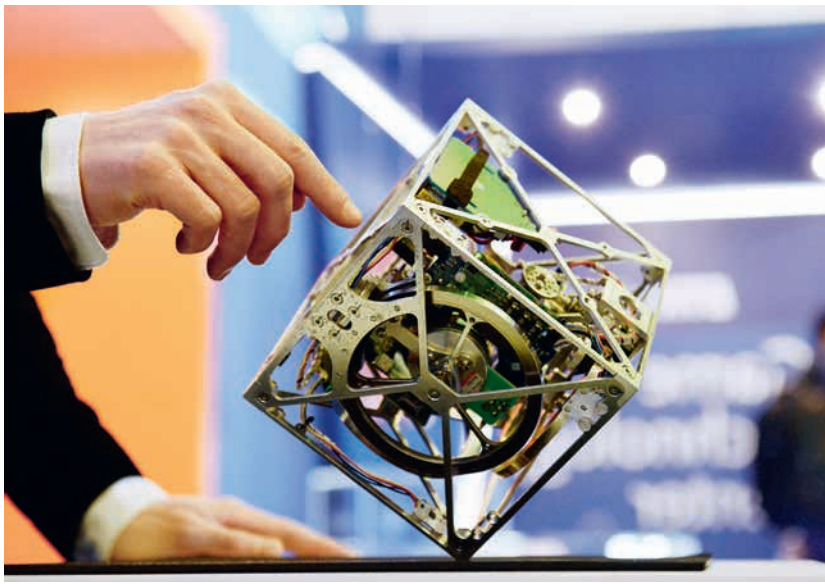
Eawag is working on the "Swiss Watercourses" programme together with the Federal Office for the Environment (FOEN) and partners from practice and science to prepare guidelines for the development of impact assessments in the revitalisation and ecological rehabilitation of hydro-power plants, and is developing them into systematic impact assessments. Widespread national cooperation also exists in biodiversity, as well as in the collection and assessment of pesticide ingress into small watercourses, taking into account climate variability and changing land use. The latter occurs within the scope of the National River Monitoring and Survey Programme (NAWA).

The Swiss Forum for Sustainable Development (eco.ch) awarded the "Gravit'eau" the main prize at "prix eco.ch 2017". Eawag collaborated on that project with the University for Life Sciences of the University of Applied Sciences and Arts Northwestern Switzerland (FHNW).

The self-sufficient Gravit'eau water kiosks in schools, villages and health centres in Uganda purify water using gravity-driven membrane filtration. They need very little maintenance, and are simple, inexpensive and robust. The technology removes bacteria, viruses and protozoa from turbid water, and allows the kiosks to be deployed, in particular, in remote rural areas in developing countries or in city slums. It is not only the technology used that makes the project sustainable, but also the fact that it is locally based. To ensure that water kiosks do not fall prey to corruption or abuse, income details must be recorded. These checks are conducted by a partner on the ground, the Uganda Water School charitable organisation. It also helps to train people from local colleges to perform the few maintenance tasks. ■

6

"The ETH Domain will continue to expand its cooperation and networking with the best institutions in the world and strengthen its international profile."



At the 2017 WEF had the ETH Zurich the opportunity to meet with national and international leading figures, and showcased its latest research findings. *(Photo: Andreas Eggenberger/ETH Zurich)*

The ETH Board's perspective

The varied international cooperation activities of the institutions of the ETH Domain underline the global image projected by the ETH Domain and its influence around the world, for instance through the presence of ETH Zurich in strategically important regions with the "Singapore ETH Centre" (SEC) and the "ETH Studio New York". The role played by ETH Zurich as a leading house in the federal government's bilateral programme to promote the research cooperation with east and south-east Asia has been a contributing factor. The EPFL's Cooperation & Development Centre (CODEV) is actively involved in many international academic networks, as well as in scientific development cooperation.

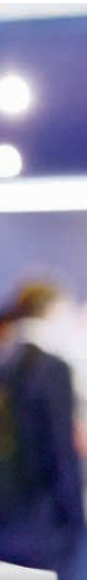
The institutions of the ETH Domain are also key partners in a number of international research infrastructures. For instance, the PSI was actively involved in setting up ESS in Lund (Sweden), XFEL in Hamburg (Germany) and SESAME in the Middle East.

2017 was shaped by new bilateral cooperation initiatives, such as those which Empa concluded with institutions in Japan, Spain and Luxembourg. They often centre around individual projects, whereby many of the cooperation initiatives that came into being in 2017 are focused on public assets. For example, Eawag is involved in a project on biodiversity and development issues in the African Great Lakes region. WSL is involved in a project on the sustainable management and protection of cultural landscapes in Europe. Various international exchange programmes for students as well as postdocs and visiting researchers serve to enhance the attractiveness of the institutions of the ETH Domain for the world's best scientists.

ETH Zurich

ETH Zurich's activities around the globe reinforce Switzerland's reputation worldwide as a centre of education, research and innovation. Consequently, the university has been commissioned by the State Secretariat for Education, Research and Innovation (SERI) to continue to act as the leading house for the bilateral cooperation programme with the east and south-east Asia region. The performance agreement for the ERI period from 2017 to 2020 was signed in 2017, and initial calls have been launched. Universities throughout Switzerland will be supported in their bilateral knowledge and technology cooperation arrangements in Asian countries with a total of CHF 3.5m.

The Singapore ETH Centre (SEC) forms the perfect platform for the promotion of this cooperation in the region. ETH Zurich has had a presence in Singapore since 2010. Nowadays, there are 160 research employees working for ETH Zurich in the CREATE campus. The Future Cities Laboratory is in its second phase (2015–2020) and is concerned with questions about the planning, concept development management of sustainable cities. In the course of the second programme, Future Resilient Systems, researchers are working to reduce the susceptibility of major complex infrastructures such as energy, transportation and communication systems to failure. A third project is planned in the field of health. ETH Zurich is also seeking to give Swiss SMEs access to the researchers' expertise and to the SEC's excellent contacts in Singapore and in surrounding countries. For that reason, it founded the Swiss Technology Impact Platform (STIP) at the SEC in 2016. This will assist Swiss SMEs in gaining a foothold in Asia. An initial study trip was held for companies in March 2017. Prof. Gerhard Schmitt took over from his predecessor Prof. Peter Edwards as the head of the SEC in 2017.



ETH Zurich was in attendance at the World Economic Forum Annual Meeting (WEF) in Davos in January 2017 with a pavilion on the theme of "Magic Through Technology". It housed a public exhibition and the TASTELAB pop-up restaurant run by the ETH spin-off FOOD-LAB. It also provided space where representatives from ETH Zurich could meet up with WEF delegates, as well as host receptions and events, including a data master class by and with the "Times Higher Education" World University Rankings. In addition to nurturing its national and international networks, ETH Zurich also used its presence in Davos to enter into dialogue with politicians, authorities and business representatives from the canton of Graubünden.

The ETH Studio New York, which was launched in 2016, was expanded in 2017. On the one hand, students from ETH Zurich spent weeks or months at companies or universities in the Greater New York region as part of their studies in Zurich. On the other hand, ETH Zurich organised two public events in Brooklyn in May as part of "ETH Meets New York", on the themes of "Machine Learning" and "Blockchain Technologies". These types of events boost ETH Zurich's visibility in this strategically important region and serve to nurture relations with academic institutions, industry and alumni.

ETH Zurich is attracting numerous high-level delegations from science, industry and politics from around the world, and this is increasingly also the case in Singapore (SEC) and New York (ETH Studio). In 2017, the university welcomed over 100 international delegations, including the President of Austria, Alexander Van der Bellen. In addition, ETH Zurich once again played host to numerous international conferences, such as the Diplomatic Courier magazine's Global Talent Summit. ■

The MOOCs Afrique programme has been part of the CODEV of EPFL since 1 May 2017. *(Photo: EPFL)*

EPFL

EPFL was ranked in 1st place worldwide in the THE "Young University Ranking", i. e. among universities which are less than 50 years old, for the third time in a row. The London-based Reuters Agency has named EPFL the third most innovative university in Europe, behind KU Leuven from Belgium and Imperial College London. This creative energy from the "EPFL eco-system" can also be measured in some cases in terms of the amount of risk capital of several million francs which the start-ups and spin-offs from EPFL have been able to procure on the world markets. One of these companies, Aleva Neurotherapeutics, which grew out of a doctoral thesis at EPFL, secured funding of USD 13m in the year under review, and has now obtained over CHF 46m in four rounds of fund-raising.

EPFL is also holding its own among the world's leading institutions in engineering and natural sciences in special rankings which are based on bibliometry and reputation studies (QS ranking: 11th and 12th in the world respectively). EPFL improved by a remarkable 16 places in the ARWU World Ranking. This was due in no small part to the quality of the new research talent at EPFL (see p. 94 ff.).

All the ranking agencies class EPFL as one of the best competence centres for computer science. It has distinguished itself in this area with a strong commitment to nationwide initiatives, above all else; such as the Swiss Data Science Center (SDSC), which is run jointly with EPFL and ETH Zurich, or digitalswitzerland. It is contributing here towards helping Switzerland and the Lake Geneva region take the lead in themes such as EdTech (education-related technologies such as MOOCs), LifeTech, artificial intelligence, cybersecurity, digital governance or FinTech. In addition, EPFL attracted more ERC grants than any other university in continental Europe, and was in fourth place behind three English universities (see p. 98 f.).

The talented mathematician Maryna Viazovska won the prestigious "New Horizons in Mathematics Prize" in December 2017 for her ground-breaking work on the theories of module shapes. Furthermore, professors Graetzel and Nazeeruddin were the most frequently cited researchers in the world during the year under review according to the Clarivate Analytics agency.

EPFL fired the starting pistol for a number of international initiatives in 2017. For example, the EPFL Extension School enhanced its range of further education courses and stepped up its efforts to involve the world's top academic institution in international cooperation networks, such as Eurotech. These networks also include the RESCIF (Réseau d'excellence des sciences de l'ingénieur de la Francophonie), which is a driving force in the joint laboratories in Vietnam, Cameroon, Senegal and Haiti. The MOOCs Afrique programme which is backed by the Swiss Agency for Development and Cooperation (SDC) and the Edmond de Rothschild foundations is to be continued with the aim of increasing capacities in third-level education in Africa.

The Centre Coopération & Développement (CODEV) at EPFL is running new courses in Development Engineering in conjunction with the University of California, Berkeley. The main objective of this emerging area of research is to cast light upon the social aspects of technological innovations. The Humanitarian Tech Hub which grew out of a partnership between EPFL and the International Committee of the Red Cross (ICRC) develops innovative solutions for humanitarian work. The EssentialTech programme was supported by the newly established SDSC in a project about artificial intelligence in collaboration with CHUV and Terre des Hommes. ■

PSI researchers Simon Gerber and Henrik Lemke: Both worked on the LCLS X-ray laser in California and are now providing their experience in the roll-out of the SwissFEL. *(Photo: Markus Fischer/PSI)*

PSI

Thanks to its expertise in the development, construction and operation of large-scale research facilities, the PSI is a respected partner in numerous international projects, such as the European Spallation Source (ESS) in Sweden or the XFEL European X-ray free-electron laser in Germany, which went into scientific operation in 2017. For its part, the PSI can benefit directly or indirectly from technical developments and expertise obtained from these systems. In particular, if systems or the technologies upon which they are based are only available in very few places worldwide, close cooperation and sustainable networks are especially important. For example, experiments could only be conducted until recently with X-ray free-electron lasers in the USA and Japan. It is all the more gratifying to know that researchers who have already gained valuable experience on the Californian X-ray laser LCLS are moving to the PSI and are using these experiences to benefit the further expansion of SwissFEL. This expertise can be used specifically to make optimum use of SwissFEL and its instrumentation, which will help to meet the needs of future users to greatest effect.

However, sustainable international networks and support for researchers in other parts of the world can also take other forms: A particle accelerator was officially started in Jordan in May 2017, the first installation of its kind in that region. The construction of the SESAME system (Synchrotron-light for Experimental Science and Applications in the Middle East) was made possible thanks to widespread international support, including from Switzerland. While the PSI spin-off Dectris provided detectors to determine the properties of the x-ray light, the PSI supplied a complete beamline for materials testing, which had previously been used on the SLS, as well as vacuum and accelerator components.

The first 30 postdocs from the "PSI-Fellow-II-3i" programme started work on their research project on the PSI in early 2017. The project, which is supported by the European Union, promotes the international mobility of new scientific talent, making a lasting contribution towards closer networking in the international and the Swiss research communities. ■

WSL

HERCULES (Sustainable Futures for Europe's Heritage in Cultural Landscapes) is a project from the seventh EU research framework programme which aims to empower public and private actors to manage and protect cultural landscapes sustainably. "Landscape" is interpreted here in the sense of the European Landscape Convention (ELC) as the combination of physical landscape and its perception. Switzerland has ratified this convention, although there was little experience of what the ELC's understanding of the landscape meant for politics, society and the economy, which was also the case in the EU member states. Therefore, 13 partners from science, NGOs and the private sector from right across Europe have joined forces in this major project which is based between natural and social sciences. On the one hand, WSL provided the benefit of its experience in the analysis of landscape history, and in particular its drivers; on the other hand, as the Swiss representative, it also ensured local contacts for the "Obersimmental" case study region. In addition to the considerable scientific output, the comprehensive understanding of the landscape which is embodied in HERCULES will make a lasting contribution towards identifying and, consequently, avoiding any unwelcome negative impact of sectoral policies more quickly and more easily. Though these activities, WSL is not only underpinning its reputation within the scientific community, but also that of solution-led Swiss research. WSL researchers are also welcome partners in EU projects in other areas of specialisation. The "PROSNOW" project, which will support ski resort areas in snow management. WSL will provide the benefit of its particular expertise in the area of snow modelling.

The WSL's Fellows Programme, which was launched a few years ago, has become well established; every year, around half a dozen leading researchers – mainly from the USA and Canada, but also from countries like Japan or France – complete a research stay at one of the WSL locations. This consolidates and promotes partnerships and often culminates in new joint research projects. ■

The "GenTree" project in Horizon 2020 researches the role of genetic resources for sustainable woodland management. WSL is the Swiss partner. *(Photo: Christian Rellstab/WSL)*

Norimitsu Murayama, general director of the Department for Materials and Chemicals at the AIST (r.) with Empa director Gian-Luca Bona. (*Photo: Empa*)

Empa

The signing of a Memorandum of Understanding has signified a decisive advancement in the close collaboration between Empa and the National Institute of Advanced Industrial Science and Technology (AIST) from Japan. Following the signing of the agreement, a variety of scientific forums took place in 2017. For example, a forum on the topic of nano-materials in Dübendorf in spring 2017 and a similar event on Energy Materials in Osaka in the autumn, which enabled Empa researchers to visit their associates in Japan. Both events are part of a series of forums with the aim of identifying the latest developments in energy research and exploiting synergy effects in the promotion of innovative solutions.

Empa has nurtured a close relationship with the "Spanish Research Council" (CSIC) in Seville for some years. This national research institution is affiliated to the University of Seville. In order to step up the collaboration, Empa has initiated a joint training programme in association with the University of Seville. Within the scope of that programme, around half a dozen grants are awarded every year to enable Master's students from the University of Seville to spend around six months at Empa working on their Master's dissertation. Each dissertation is assigned two supervisors, one from CISC/University of Seville and one from Empa. The agreement was signed in September 2017. The first cohort will get started on their Master's dissertation at Empa in summer/autumn 2018. In the medium term, a titular professorship will also be created for an Empa scientist at the CSIC/University of Seville in order to further step up the scientific cooperation.

Empa has also agreed a research cooperation arrangement with the University of Luxembourg, with a view towards advancing the design of buildings with reusable components. Representatives from both institutions signed a Memorandum of Understanding in Luxembourg on 27 October. The building sector causes considerable CO_2 emissions, consumes lots of resources and generates huge mountains of waste. Therefore, there is an urgent need for ecologically sound construction methods. The "Eco-Construction for Sustainable Development" (ECON4SD) project is geared towards the development of innovative components and design models for buildings. It is intended to make them more resource and energy-efficient. ■

Eawag

Collaboration within international networks is of pivotal importance to Eawag. Both the international nature of the researchers and the interdisciplinary partnerships create valuable synergies for research projects and boost their effectiveness. Therefore, Eawag researchers are actively involved in more than 70 international committees and networks spanning the globe. If one includes visiting academics, women and men from over 50 countries carried out research at Eawag in 2017. For instance, an Australian environmental historian was commissioned by Eawag to work on the project "Flows of Science: A History of Collaboration on Source Separation Technology at Eawag". He is documenting how the technology for separating wastewater at source came about at Eawag and how this has influenced other projects. Conversely, Eawag researchers in Africa worked on a report which was published by the African Great Lakes Information Platform. It is concerned with biodiversity and development questions in the context of conflicts of use and climate change. The primary focus of the Eawag contributions was on gaining a better understanding of the particularly great biodiversity of the African Great Lakes region and researching their significance to ecosystem services.

Sewage works in Europe could soon be transformed from energy consumers to energy producers. There is a latent energy potential of 315,000 TJ in European sewage. If this potential was exploited, for example through the fermentation of sludge into biogas, this could produce just as much energy as twelve conventional large power stations. This is precisely what the "Powerstep" project is hoping to achieve. In addition, a liquid fertiliser will be produced as a by-product. The project, which has 5m EUR of backing and involves a large number of European partners, is co-funded through the EU's "Horizon 2020" framework research programme and is set to run until 2018. Eawag is involved in it with a case study on the Altenrhein sewage treatment plant. ■

Energy harnessed from sludge through fermentation into biogas thanks to "Horizon 2020". *(Photo: Eawag)*

7

"The ETH Domain maintains a dialogue with society and performs tasks in the national interest."

"Globi and the Crazy Machine" is the name of the 87th issue of the Globi publication. What the title does not reveal is that he is playing at ETH Zurich. About 30 children had the chance to meet Globi during the book launch at ETH. *(Photo: Nicola Pitaro/ETH Zurich)*

The ETH Board's perspective

The ETH Board maintains the dialogue with the general public in a variety of ways and with great feedback. It is also committed to the promotion of STEM subjects. For example, ETH Zurich and EPFL have already stepped up their not insignificant efforts to share their fascination with STEM subjects with children and teenagers – and, more especially, with girls – and have once again reached out to more participants with their courses. From a geographical perspective, the courses are being made accessible to an ever wider group of children and teenagers; EPFL is increasing its targets at its external locations in the cantons of western Switzerland. Great efforts are also being made by the research institutes, such as the PSI; iLab, its laboratory for school children, has consistently high visitor numbers.

On the one hand, dialogue with wider society entails very well-attended events for the general public and numerous cooperation projects with specialist companies and associations. All the institutions of the ETH Domain maintain this with lasting success. On the other hand, there is also a need for specific contributions towards sharing scientific findings with policy-makers and the media. Many of the events held by the institutions of the ETH Domain are characterised by the key themes of digitisation and climate change. The ETH Domain is particularly keen to engage with the general public on these two great challenges of our age. It feels sure that it can make decisive contributions towards dealing with them. In this context, the involvement in Digital Day or the trip to Greenland with politicians, including the then former Swiss President Doris Leuthard, and media representatives merits special mention. This allowed the impact of climate change to be illustrated on the basis of a specific example and to be shared with a wider audience through the media.

ETH Zurich

A number of events put on for the public at ETH Zurich in 2017 focused on the challenges of digitalisation for research and society. Over 30,000 visitors to Scientifica, the Zurich Science Days event, in September 2017 wanted to know "What data reveals". Researchers at ETH and the University of Zurich showed how digitisation has not only brought about changes in areas like robotics or climate science, it has also changed language and cultural science. For the first time ever, there were also ten spin-offs of ETH and of the University of Zurich in attendance, demonstrating how they have transformed digitisation into new business ideas. The Science City conference in spring 2017 explored "Work in World 4.0" and brought around 20,000 people of all ages to ETH Zurich. The Cyber Risks Summit in June brought together international experts to discuss the latest scientific and technological approaches that society could take to protect itself effectively against threats within cyberspace. The event was organised by the Zurich Information Security & Privacy Center (ZISC) at ETH Zurich. This centre has been conducting research in the area of information security for 15 years. And finally, ETH Zurich was involved in the first national Digital Day in November 2017.

ETH Zurich not only wants to wow the public with science events, it also wants them to become engaged in its research activities. With that in mind, it founded the Citizen Science competence centre in association with the University of Zurich in January 2017. This creates a platform to enable non-scientists to take part in university research projects via special online networks without having to get around any red tape. Nowadays, hundreds of thousands of ordinary people are helping to analyse telescopic images of the sky and to categorise galaxies.

To help children to nurture a love of science at a very early age, comic book hero Globi paid a visit to ETH Zurich in 2017. In "Globi and the Crazy Machine", the 87th issue of the Globi publication,

our hero is invited into a professor's laboratory, where he is unexpectedly shrunk by the machine in the title. 30 children also attended the official book launch at the focusTerra earth science information centre at ETH Zurich. They got to see the places and objects, which appear in the book, at first hand, including the robot dog StarlETH, the earthquake simulator and a 3-D chocolate printer.

ETH Zurich has been working closely with secondary schools for many decades. The introduction of information technology as a subject in primary and secondary schools has presented them with a great challenge. The Training and Advice Centre (ABZ) for Information Technology at ETH Zurich offers support for key stage-appropriate IT teaching skills. It develops textbooks and teaching resources, including teaching sequences which can be used directly in the classroom. In addition, it delivers CPD training to teaching personnel at all key stages.

To enable all school leavers to progress onto a Bachelor's degree course, ETH Zurich also offers a free bridging course in mathematics. It helps with repeating and refreshing secondary school-level mathematics independently. The prerequisite is to take a self-assessment test, which 1680 pupils did in the year under review, gaining admission to the bridging course.

Once again, 6,740 secondary school pupils came along to ETH Zurich in September 2017 to attend the Study Information Days for ETH and the University of Zurich. In addition, the university visited six secondary schools around the country as part of the "ETH on the road" initiative. ■

The Data Square exhibition in the ArtLab is dedicated to two major big data projects, Venice Time Machine and Blue Brain. *(Bild: Adrien Barakat/EPFL)*

EPFL

More than 10,000 children and teenagers aged between 7 and 16, as well as hundreds of their teachers from western Switzerland, enjoyed a wide range of different activities as part of the programme entitled "Les sciences, ça m'intéresse!", which is meant to introduce young people to science and technology and spark their interest in the STEM subjects.

For example, 700 girls aged between 9 and 15 took part in information technology and robotics workshops that had been specially designed for them. In collaboration with the canton of Jura, these scientific and technical workshops were held for the first time in thirty school classrooms in the cantons of Bern, Neuchatel and in the north of the canton of Vaud. 300 schoolchildren aged between 8 and 16 had fun at coding and programming workshops at the first Swiss Digital Day at EPFL on 21 September 2017.

Kids and adults also got to go on a voyage of discovery outside the EPFL campus. EPFL ran scientific and technical semester courses and workshops for children aged between 7 and 13 at the campuses in Fribourg, Sion, Neuchatel and Geneva. "Scientastic", the EPFL festival of science, that was held for the very first time at the EPFL Valais Wallis campus in Sion and at the Microcity campus in Neuchatel, proved to be a great success, attracting 4,100 and 4,500 visitors respectively.

"Campus durable EPFL" celebrated its tenth anniversary. A comprehensive programme of activities was presented on this occasion and, at the end of 2017, a new Sustainability Strategy for 2018–2020 was adopted by the Senior Management. The Real Estate and Infrastructure section went to great lengths to increase energy efficiency, resulting in sustained savings of 4 GWh in total. In mobility, a new system of parking management with increased fees and flexible cashless parking enabled the growing number of motor vehicles to be kept in check. At the same time, a 15% discount was introduced on employee subscriptions for season travel passes on the Mobilis network.

Travel for work is also an important issue. This is borne out by substantiated data analyses by the travel office, which reserves 80% of flights for EPFL employees. Therefore, part of the future strategy is a programme for reducing and offsetting work-related travel.

The introduction of washable dishes in the restaurants and food trucks on the EPFL campus led to a considerable reduction in volumes of waste. Following the successful trial phase, the experiment was rolled out and continued in 2018. Employees also had the chance to take part in the "Act for Change" team competition in 2017. The objective is to make every individual aware of how lead to a sustainable lifestyle on campus through simple small actions. This was the fourth time that the competition had been held, and around 700 employees took part (see p. 113).

The ArtLab recorded a considerable number of visitors with 31,000 admissions. Opened on 3 November 2016, it keeps pace with the rapid development of digital humanities. EPFL has boosted this trans-disciplinary area by creating a Master's degree programme and four laboratories. The ArtLab is an extension to this infrastructure and, at the same time, offers a unique experimentation platform, connecting culture, technology and science. The digitisation of our cultural heritage is of interest if it is organised and can be unveiled to the general public – whether it be the archive of the Montreux Jazz Festival or the State Archive of Venice. Researchers and artists can take chances and try out possibilities in the ArtLab, which also benefits traditional cultural institutions. The ArtLab brings the depth of colour in Pierre Soulages' outrenoir pictures to life (see p. 70). ■

The inner workings of the model containers for the energy supply to Esiville can be illuminated with the aid of an "X-ray station". *(Photo: Mahir Dzambegovic/PSI)*

PSI

With a varied range of events, guided tours for visitor groups and exhibits in the 'psi forum' visitors' centre, the PSI promotes close dialogue with the general public. It demonstrates current scientific findings as well as forward-looking research topics to visitors and gives them an insight into its large-scale research facilities, the likes of which can only be found nationwide in the PSI. A new visitors' facility exploring the theme of energy supply was opened in February 2017 in an effort to give visitors an understanding and hands-on experience of current key research themes and the installations used for them at the PSI. Since then, this information has been presented to them on guided tours. "Esiville", the model town populated with Playmobil figures, is intended to illustrate the topic of the every more complex energy supply system, as well as the associated challenges and solutions. Based on the concept of the Energy System Integration (ESI) platform of the PSI, which is used for testing and integrating various storage concepts (power-to-gas) for renewable energy, a miniature ESI platform has been assembled at the visitor's station, illustrating the interaction between different technologies.

The annual "Apprenticeships à la carte" event attracted some 680 visitors to PSI in June, offering an excellent platform for telling prospective students about the training courses available at the PSI in 15 different careers, similar to the Aargau Careers Fair in September. The PSI also makes an active contribution towards the development of new talent in the STEM subjects with the operation of the iLab laboratory for schoolchildren, which is visited by over 200 school groups a year.

Since back in the mid-1980s, the PSI has operated the Center for Proton Therapy for the treatment of patients with ocular melanomas and deep-seated tumours, playing an important role in cancer therapy for the Swiss healthcare system. The national tasks undertaken by the PSI also include the annual campaigns for the collection of radioactive waste from medical, industrial and research facilities, carried out on behalf of the Federal Office of Public Health (FOPH) and the role of contact for the federal government and supervisory authorities on radioactive waste and safety issues in Swiss nuclear installations. ■

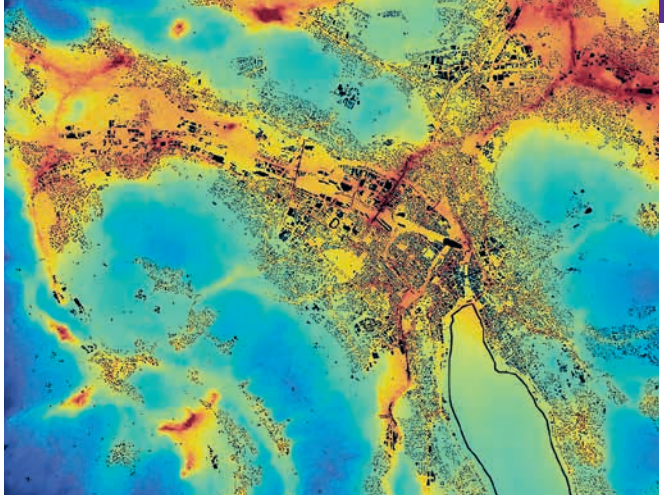
WSL

Given the tasks taken on by WSL – woodland, landscape, biodiversity, natural hazards, snow and ice – ever-present aspects of the research done at WSL include climate change, its impact on people and on nature, as well as society's scope to take action. This gives rise to important findings for ways of limiting climate change and dealing with the impact of it. Researchers from WSL regularly also present their findings to the general public and to decision-makers. The director of WSL, Prof. Konrad Steffen, is also committed to this task of communicating scientific findings. He co-organised and hosted the "Arctic Basecamp Davos" at the SLF (Snow and Avalanche Research) as part of the fringe programme for the WEF, accompanying the then Swiss President Doris Leuthard – together with other scientists and the President of the ETH Board, Fritz Schiesser – to Greenland, where the federal council member could see for herself the correlations between melting glaciers and climate at the SwissCamp research station.

As an environmental research institution most notably, WSL goes to great lengths to act sustainably within its area of responsibility. Therefore, refurbishing the energy installations was of great importance in the renovation of two buildings dating back to the 1950s. As the first administration building in the Zurich area to undergo modernisation, the buildings now meet the criteria for double certification for modernisation in conformity with the two building standards, i. e. Minergie-P-ECO and Minergie-A-ECO.

Whenever local people, politicians, media people or researchers have a question nowadays, they get out their smartphone and Google it, whether they are at home, in the office or out and about. By the same token, well-structured websites which are accessible with all devices have also become indispensable tools for public relations, reputation management and knowledge transfer. Therefore, WSL has completely updated its websites www.wsl.ch and www.slf.ch (including the avalanche warning products) technically, conceptually, graphically and in terms of content. WSL places particular importance on its language concept, duly including German, French and Italian as official languages and English as the language of science. ■

WSL director Konrad Steffen and other scientists explain the impact of climate change to the then Swiss President Doris Leuthard in Greenland. *(Photo: Konrad Steffen/WSL)*



Distribution of the CO_2 concentration throughout the city of Zurich. Thanks to the measurement readings from the sensor network, these model calculations will be more precise in the future. *(Photo: Empa)*

Empa

New car exhaust emissions regulations came into force in the EU and Switzerland on 1 September 2017. These regulations close gaps in the current emissions legislation and ensure that diesel vehicles, in particular, are discernibly cleaner, especially with regard to their nitrogen oxide emissions. The new regulations essentially include three changes: Firstly, the outdated measuring methodology is to be replaced; secondly, exhaust emissions must also be measured while vehicles are travelling along roads; and thirdly, manufacturers must disclose the engine control unit which is related to exhaust gas purification. However, the most important innovation is the introduction of roadside measurements which reflect reality. Working in association with experts from the Federal Office for the Environment (FOEN), from the Federal Roads Office (FEDRO) and from Bern University of Applied Science, researchers from Empa have played a significant part in the development of a new exhaust gas measuring method, the "World-wide Light Duty Vehicle Test Procedure" (WLTP). This ensures that the discrepancy between laboratory measurement readings and real emissions is reduced considerably in future.

Thanks to Empa, Switzerland's tightly knit CO_2 measuring system is the only one of its kind in the world. While there have only been three measuring stations dotted across Switzerland up to now, i.e. in Dübendorf, Beromünster and on the Jungfraujoch – in future, there will be 300 sensors recording changes in the CO_2 concentration in the atmosphere in terms of space and time. Empa has developed a model for the city of Zurich, where the sensor network will be particularly tightly structured, simulating the CO_2concentration from ten different sources. These emission sources include, for example, different types of traffic, industry and heating systems in residential housing. By linking these simulations to the sensor data, it will be possible to create visualisations of current CO_2 emissions in the city. The scientific and technical applications based on the sensor data which is collected throughout Switzerland, in turn, will serve as a starting point for transport planning, health prevention, "smart cities"-related developments and for gaining a better understanding of the exchange of CO_2 between the atmosphere and vegetation. ■

Eawag

In 2017, Eawag once again made a significant contribution towards training and networking in the water sector. The central partners in this were the Water Supply Association (SVGW) and the Swiss Water Association (VSA). The two VSA platforms "Process Technology for Micro Impurities" and "Water Quality" are areas of cooperation between the Swiss Water Association, the Federal Office for the Environment (FOEN) and Eawag. They are organisationally affiliated to the VSA and are integrated into the research departments at Eawag. They maintain databases with background information and act in an advisory capacity for local authorities, cantons and private individuals.

Eawag held a conference on decentralised wastewater purification with the VSA in 2017. Geogenic pollutants, i.e. those naturally occurring in the ground, in groundwater and drinking water were discussed at a conference together with the SVGW. Together with the Swiss Association of Environmental Cycle Paths, Eawag also opened an interactive adventure station for the general public on the theme of "How we use and experience streams and rivers?" on the revitalised Chriesbach in Dübendorf (see also p. 112). Eawag is also involved in the online course on "Water in Switzerland" run by the University of Zurich, which is also aimed at members of the public with an interest in this.

Biologists from Eawag and from Zurich University of Applied Sciences (ZHAW) conducted a joint study on the Solis reservoir in Graubünden. It reveal that sediment bypass tunnels, which reduce sediment deposits in reservoirs, also have a positive impact on the ecological conditions of the stretches below. Bypass tunnels come into play in flood scenarios, in particular, conducting alluvial rock material around a reservoir and on into the downstream stretch. There are currently twelve bypasses in Switzerland, with others planned. These bypasses provide a more natural flow and sediment dynamics which are otherwise absent in regulated watercourses. Operational and ecological needs can be combined with sediment bypasses. ■

A bypass tunnel near Tiefencastel transports the sediment downstream in the event of a flood. *(Photo: ewz-Medienarchiv/Matthias Kunfermann)*

National tasks

Selected national tasks

Serving the economy, society and the environment, the ETH Domain fulfils numerous national tasks in the interest of the entire nation. In many cases, these tasks are explicitly rooted in the law, are activities of the institutions that have evolved over time or are tasks of the Federal Government that have been integrated in the ETH Domain. Apart from the national tasks listed below, some other examples deserve a mention: the Swiss Economic Institute (KOF), the ETH library, the Swiss Plasma Center, the Swiss National Forest Inventory (NFI), the plant protection laboratory, avalanche warning system and large-scale research infrastructures of national importance such as the Swiss Light Source (SLS).

ETH Zurich

"Swiss World Atlas" reissued

The "Swiss World Atlas" has been a loyal companion to pupils in geography lessons since 1910. 2017 saw the publication of a completely revised new edition. Thanks to the great strides that have been made in collecting and processing data, researchers from ETH Zurich have been able to develop completely new types of maps. For example, maps of the economic power of global urban centres or of intensity of agricultural use with proportions of arable farming and pasture land. The printed version of the atlas will be accompanied by a website containing additional materials, commentaries and interactive program tools. The latter permit dynamic and some three-dimensional access to topics such as the shape of the earth, map projections and the apparent movement of the sun in the sky. The "Swiss World Atlas" is one of the first geography resources to be adapted to the new *Lehrplan 21* curriculum.

schweizerweltatlas.ch

ETH Zurich

150 years of the *Graphische Sammlung*

The *Graphische Sammlung* (Graphic Collection) at ETH Zurich celebrated its 150th anniversary in 2017 with multiple exhibits and a varied fringe programme under the motto *Blickwechsel* (Change of View). With its high-calibre art collection, it is one of the largest and most important collections of its kind in Switzerland and enjoys great international acclaim. The collection houses around 160,000 works, including some by Pablo Picasso, Dürer, Rembrandt and Goya, as well as Warhol or Fischli/Weiss. The *Graphische Sammlung* is of special importance to ETH Zurich because the university lays great store by giving its students as rounded an education as possible. Art can deliver important impetus here and inspire questions that cross disciplines. The contents of the collection will be researched and digitised in the next few years.

gs.ethz.ch

EPFL

ArtLab – The experimental platform

Opened on 3 November 2016, ArtLab accompanies the rapid development of the digital humanities. EPFL consolidated this interdisciplinary science with the creation of a Master's qualification and four laboratories. ArtLab complements this infrastructure and offers a unique platform for experiments, combining culture, technology and science.

The digitisation of our cultural heritage is only of any interest, above all else, if it is organised and made accessible to the general public – whether it be the archive of the Montreux Jazz Festival or the State Archive of Venice. Researchers and artists can take chances and try out possibilities in the ArtLab, which also benefits traditional cultural institutions. Thanks to the ArtLab, the public got to experience the chromatic intensity of Pierre Soulages' "Les Outrenoirs", compare the scientific views of artificial intelligence with those of the *!Mediengruppe Bitnik* media collective, or capture the brain-machine interfaces in an artistic context.

artlab.epfl.ch

Pupils learn to work with the Swiss World Atlas from their early years in secondary education. Researchers at the Institute of Cartography and Geoinformation at ETH Zurich, have taken editorial responsibility for the fully revised new edition. *(Photo: Andreas Eggenberger/SWA)*

Summer exhibition entitled "Come chat with me" by *!Mediengruppe Bitnik*. *(Photo: Adrien Barakt/EPFL)*

OPTIS2, the therapy facility for the treatment of ocular tumours, is based on the OPTIS irradiation system. *(Photo: Mahir Dzambegovic/PSI)*

PSI

Proton irradiation of ocular tumours: a success story

Patients with rare ocular tumours have been treated with proton irradiation at the PSI for over 30 years. The foundations for this success story were laid with the launch of the OPTIS irradiation plant, which was developed at the PSI, at the Center for Proton Therapy in 1984. Sometimes there are tiny tumours at the back of the eye which lead to a loss of vision or of the whole eye. They can be irradiated without jeopardising the other structures of the eye. In the intervening years, over 6,700 patients have received treatment, more than at any other proton therapy facility in the world. The statistics confirm the success of the treatment method: they have managed to save the eye in over 90% of patients so far.

WSL

Avalanche bulletin: Contributing towards safety in Switzerland

Issuing avalanche warnings is probably the WSL's most well-known national task. As popular as this service may have become for snowshoe trekkers, freeriders and touring riders, it is essentially aimed at key safety personnel from local councils, cantons, ski resorts and transport providers. A study conducted by the WSL on deaths from natural hazards in Switzerland has revealed that there has been a clear decline in the number of avalanches in built-up areas and on open roads over the past seventy years, even though there are now many more people (including tourists, in particular) venturing up into the mountains. The reliable forecast of the risk of an avalanche by the SLF is likely to be a key factor in this.

slf.ch/de/lawinenbulletin-und-schneesituation

(Photo: Jürg Schweizer/SLF)

Empa

NABEL with national and international impact

The National Air Pollution Monitoring Network (NABEL), a joint project by Empa and the Federal Office for the Environment (BAFU), measures air pollution at 16 typical locations in Switzerland. This activity is anchored in the Air Purity Ordinance and is used to assess the development of air quality, as well as those measures which have been taken to ensure air purity and those which are still necessary. A new NABEL measuring station was created at the former Beromünster transmitter tower in 2017. It forms the research basis for measuring anthropogenic and biogenic emissions, making it a central element for decision-making in the future. Like the other NABEL stations, Beromünster is also integrated into international programmes, transmitting well beyond its national borders.

Eawag

Quality of Swiss rivers and lakes

On behalf of the Department of Radiation Protection at the Federal Office of Public Health (FOPH), Eawag uses its gamma-ray laboratory to continuously monitor radioactivity in aquatic systems. Together with the WSL and the FOEN, it is involved in the National River Monitoring and Survey Programme (NAWA). NADUF tracks the concentrations of substances occurring in Swiss watercourses. The ongoing national studies into substances in Swiss rivers (NADUF) has been integrated into NAWA.

Eawag

Swiss Centre for Applied Ecotoxicology

The Eawag-EPFL Ecotox Centre completed the review of effect-based quality criteria for over 50 micro-impurities in rivers and lakes in 2017. The values will initially be sent by the Department of the Environment, Transport, Energy and Communications (DETEC) to a public hearing in order to then transpose the numerical requirements into the Swiss Water Protection Ordinance. The Ecotox Centre has also demonstrated that pollution from pesticides in small streams in Switzerland brings with it an eco-toxicological risk. A key reason for this is that water-borne organisms are being deprived of recovery phases as a result of continuous pollution.

ecotoxcentre.ch

8

"The ETH Domain is expanding its financing base and seeks to ensure that the funding is used cost-effectively and in compliance with strategies."

The ETH Board's perspective

The base of financing of the ETH Domain remains solid despite a slight decrease in third-party funds.

The proportion of financing accounted for by third-party funding held firm at around 27 %. The share is also dependent on the development in the total federal contribution, which was markedly up in 2017 on the previous year.

Joint initiatives and projects promote synergy effects in the ETH Domain and contribute towards the increase in efficiency.

Total federal contribution

The total federal contribution from the Federal Government is the most important source of financing for the ETH Domain. The budgetary framework requested by the Federal Council in the ERI Dispatch for 2017–2020 (Ø 1.9 % growth) was increased in a resolution adopted by the Federal parliament by CHF 160m to CHF 10,337.8m. Due to austerity measures for the period 2018–2020 the funds made available for the period 2017–2020 will be reduced to CHF 10,148.2m. This corresponds to an average yearly growth of just under 1% (see fig. 2).

Allocation of funds based on relevant criteria

Article 33*a* of the ETH Act[1] requires that the ETH Board allocate the federal funds on the basis of its target agreement with the two Federal institutes of Technology and the four research institutes and their budget requests. The allocation of funding within the ETH Domain is governed by Article 12 para. 2 of the Ordinance for the ETH Domain[2].

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 credits for 2017 totalled CHF 2,530.8m; after deduction of ring-fenced expenses (current projects, administration of the ETH Board and ETH Appeals Commission, strategic projects including incentive and initial funding amounting to a total of CHF 142.7m), this meant that there was an allocation of funding of CHF 2,386.4m. CHF 2,351.2m is allocated for the basic mandate and CHF 35.2m as performance-related awards (see fig. 5).

Funding for the strategic projects of the ETH Domain/own consumption by the ETH Board's staff:

- Research infrastructure: CHF 58.3m
- Strategic focus areas: CHF 27.0m
- Incentive and initial funding, as well as other central expenses: CHF 42.6m
- Administration of the ETH Board and ETH Appeals Commission CHF 14.8m

[1] SR 414.110
[2] SR 414.110.3

Fig. 2: Budgetary framework for the ETH Domain in the ERI 2017–2020 period (as of February 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 ETH Domain – increase		**40.0**	**40.0**	**40.0**	**40.0**	**160.0**
Budgetary framework of the ETH Domain 2017–2020 FD 4 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

The total federal contribution consists of two credits: credit A231.0181 federal financial contribution covers the financial requirements for current outgoings, and credit A202.0134 Investment credit constructions of ETH Domain covers the investments (see fig. 3).

Fig. 3: Credits taking into account the budgetary framework of the ETH Domain (as of February 2018)

CHF millions	2016	2017	2018	2019*	2020	2017–2020
A231.0181 Federal financial contribution	2,288.7	2,377.9	2,332.4	2,312.0	2,332.6	9,355.0
A202.0134 Investment credit for ETH Domain constructions	165.1	152.9	198.5	228.9	212.9	793.2
Total credits, taking into account the budgetary framework	**2,453.8**	**2,530.8**	**2,530.9**	**2,540.9**	**2,545.6**	**10,148.2**
Nominal growth in CHF		77.0	0.1	10.0	4.6	
Nominal growth in %		3.1	0.0	0.4	0.2	
Ø annual growth 2017–2020 (based on 2016 budget) in %						0.9
Expecting cinsumption of credits entitlement on the budgetary framework in %						98.2

* The 2019 and 2020 budget will only be adopted in June/July 2018.

Third-party funding

A considerable share of the financing for the ETH Domain is done via third-party funds[3]. They include research contributions from the Federal Government and funds from SNSF and Innosuisse, as well as those from federal government research and via funding from EU framework programmes (EU-FP). The share decreased slightly, compared to the previous year's high level (2017: CHF 540m; 2016: CHF 550m). Expectations (B 2017: CHF 508m), however, were exceeded. Research contributions from the cooperation with the private sector (CHF 130m) were in line with the budget. However, this is down slightly on the previous year (–3.8%). The total of other third-party funding, donations and various revenue streams exceeded expectations and was above the previous year's figure.

The share of the entire third-party funding, measured by operating revenue, was 27.1% in the year under review. The share has remained constant compared to the previous year (2016 statement: 27.7%). Measured in absolute terms, the total third-party funding was higher in 2017 than it had been in 2016. The development in current and non-current non-exchange transactions or in dedicated third-party funds from contracts in accordance with IPSAS 23 from the balance sheet are to be factored into the evaluation. A rising volume compared to the previous year is a positive indicator of the expansion of the financing base. This was the case in the year under review. The dedicated third-party funds entered in the balance sheet (2017: CHF 1,428m) was well up on the previous year (CHF +94m). 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; however, this will also impact upon the operating income in terms of absolute figures.

The indirect costs of third-party funded projects are offset in each case, so that the basic mandate has not been affected by these costs.

[3] Second-party resources 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, mandates and scientific services'. The erstwhile third-party funding includes business-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. 4).

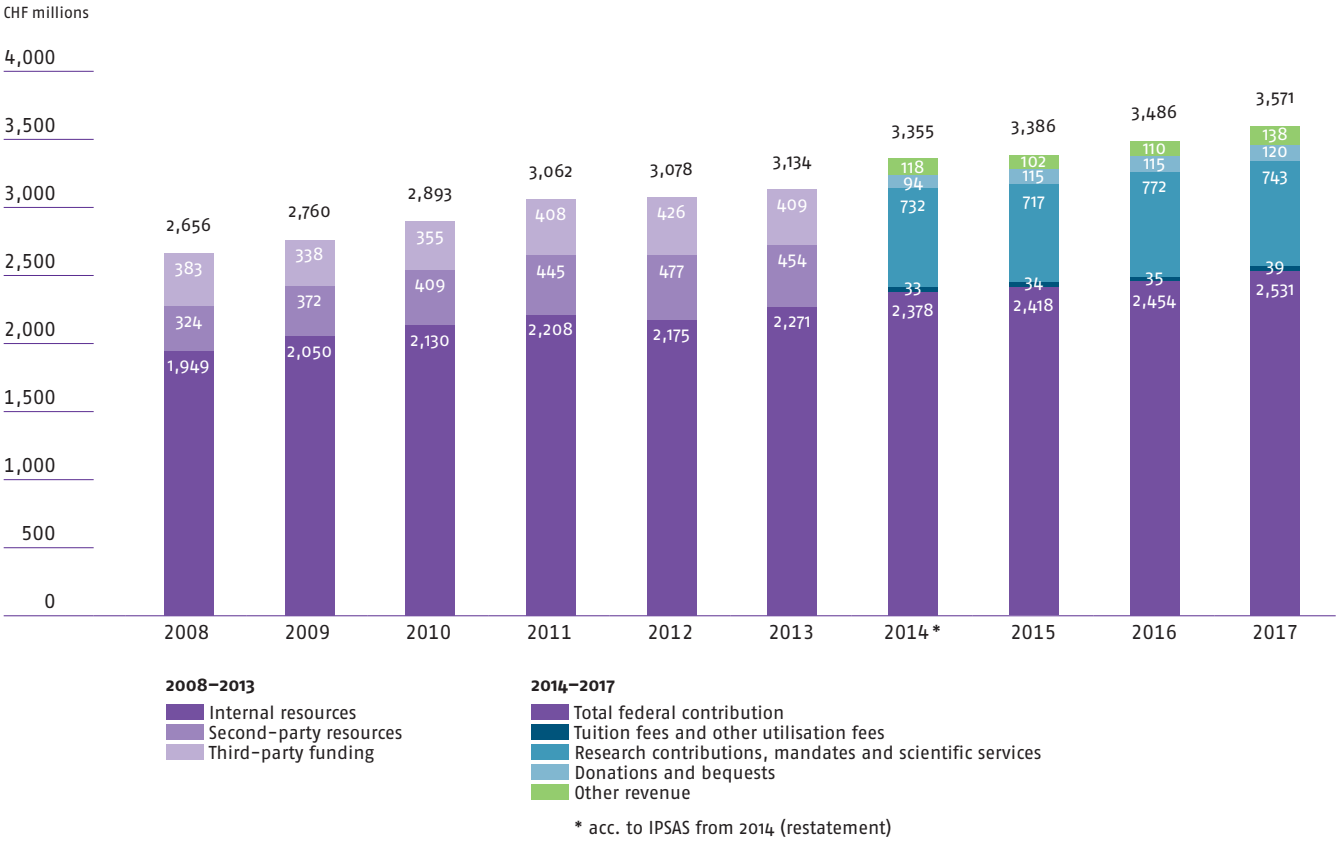
Maintaining teaching and research freedom

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 cooperations.

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), central projects such as NRS (new accounting standard IPSAS) 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.

Fig. 4: Development of the sources of financing



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, which has been established within the framework of the strategic focus area Data Science (see p. 10), and the Energy System Integration (ESI) platform of PSI, Empa and ETH Zurich (see p. 22 f.). 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 at the Valais Wallis campus and in Dübendorf. The most important international rankings are also a key indicator of efficiency (see p. 94 ff.).

Dismantling and disposal of the PSI accelerator plants

There is a 40-year timescale for the accrual of the provision of CHF 426m for accelerator plants at the PSI. By the end of 2017, a total CHF 12.0m had been set aside (2017: CHF +5.0m). The PSI used CHF 0.8m of that in the year under review 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. 38.

Fig. 5: Allocation of funding to the institutions of the ETH Domain

						Δ 2016 / 2017	
CHF millions	2013	2014	2015	2016	2017	abs.	%
ETH Domain [1, 2, 9, 10]	**2,271.4**	**2,378.2**	**2,417.9**	**2,453.8**	**2,530.8**	**77.0**	**3.1**
ETH Zurich [3]	1,146.8	1,212.5	1,224.0	1,247.2	1,297.4	50.2	4.0
EPFL [4]	580.9	594.9	618.1	640.3	666.2	25.8	4.0
PSI [5, 8]	303.2	300.4	324.0	305.4	294.3	−11.2	−3.7
WSL	55.6	53.0	55.7	55.9	58.7	2.8	5.0
Empa [6]	97.3	106.8	106.7	110.7	114.7	3.9	3.5
Eawag	55.5	56.1	58.6	59.1	61.5	2.4	4.0
ETH Board [7]	32.2	54.6	30.7	35.1	38.2	3.1	9.0

Additional information on the financial statements 2017:

[1] Total allocation of funds in 2017 including an award (CHF 35.2m) 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 2017: CHF 2,529.1m / Federal resolution on the budget according to Federal resolution Ia estimate for 2017: CHF 2,530.8m
[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 22.9m, start-up funding President: CHF 3.0m
[5] Including ATHOS / SwissFEL: CHF 5.0m, Action Plan Energy PSI: CHF 3.0m
[6] Including real estate portfolio adjustment: 2017: –
[7] Including strategic projects, financing the dismantling of accelerator systems at the PSI (CHF 5.0m), 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 1.7m)
[9] Including strategic focus areas (personalised health and related technologies, data science, advanced manufacturing) (total: CHF 27.0m)
[10] Including research infrastructure (upgrade to CMS detectors at CERN, Swiss Plasma Center) (total: CHF 7.5m)

9

"The ETH Domain coordinates the management of the properties and real estate, and ensures the preservation of their value and functionality."

Recap by the ETH Board

The ETH Domain's real estate portfolio is an important factor in its ability to maintain its leading standing in teaching and research among institutions internationally. As a centre of science, Switzerland as a whole benefits from this. The utmost importance is placed in the ETH Domain on the long-term focus on needs and the conscious efforts to lead by example in sustainable real estate management. The tried and tested management and control instruments introduced in previous years, such as the Spatial and Financial Master Plans (SFMP) or the Internal Control System (ICS) in real estate management, make just as important a contribution as the risk management system, which went into operation in the year under review.

Long-term portfolio development

In order to meet the ambitious strategic targets of the Federal Government as the owner of the ETH Domain and as the owner of the real estate that is used by the ETH Domain, the ETH Board is working with the institutions to develop the real estate portfolio further in line with needs. The primary objective is to ensure that the building and technical infrastructure required for teaching and research in accordance with strategic planning can be made available at the right time. With the ETH Board having checked and approved the long-term plans of five institutions in the previous year in the form of Spatial and Financial Master Plans (SFMP), EPFL presented its SFMP 2017–2020 for approval in 2017 following the change in the Presiding Committee. In addition, the SFMPs from Empa, Eawag and from the PSI were also added. Consequently, the ETH Domain's real estate management has consistently further developed its target and customer-oriented approach, including in the sense of the owner.

The growth in core business (teaching, research and KTT) and the increasing requirements in terms of infrastructure also entail a rise in financial demands. The demand for space, i. e. the foreseeable space requirement, is raising even under efficiency scenarios such as occupancy densification. Increasingly, flexibilisation of job allocation is taking effect. In 2017, the Federal Council adopted one austerity programme and one efficiency programme. These relate to the so-called investment credit constructions for ETH Domain, which has an impact on investment planning for the coming years 2018–2021. Corresponding adjustments were made by the senior management and by the directorates of the two Federal Institutes of Technology and the research institutes. Some construction projects were stopped, postponed or canceled altogether. The cuts can be partially absorbed by the delays in construction projects already commenced.

The ETH Domain faces up to this challenge, maintaining its intention to continue to provide with its real estate suitable conditions in order to fulfill the teaching and research objectives, as well as to meet the high standards set by the Federal Government and the ETH Domain in the field of energy, environment and building culture in the coming years.

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. In order to comply with the right of the Federal Government to be given information, details of expenditure will be collected separately, and the state of the individual properties will be determined applying standard methodology, will be accumulated at portfolio level 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 84,7% determined in 2017 remains constantly high in relation to the new value (see fig. 29, p. 108). Consequently, the ETH Domain has demonstrated that it is using the building stock provided by the Federal Government responsibly and sustainably.

Sustainable development

The Federal Council has published a document every four years since 1997 setting out its policy intentions on the implementation of sustainable development in Switzerland, currently in the form of the "Strategy for Sustainable Development 2016–2019". An important part of this strategy is the example that the Federal Government is meant to set as the owner and operator of real estate and infrastructure. The institutions of the ETH Domain support the objectives of the strategy within the scope of their real estate management. Part of this support takes the form of pilot and beacon projects in which new technologies, materials and building processes are tested with the aim of reducing the environmental impact of the construction and operation of infrastructure installations.

Where several buildings with exemplary sustainability features went into operation in 2016, the focus in 2017 was on measures that were comparatively small by comparison. It should be emphasised that the initiative of the WSL in 2017 served to offset the rest of the CO_2 emissions that had been caused by it (building and mobility) in 2016 by purchasing certificates. The WSL's intention is to heat and cool its building at least 98% CO_2-free by 2020. It is seeking to expand photovoltaic systems at the institutions further with the same objective in mind. A system went into operation at the PSI, as well as one at WSL in 2017. The scientifically backed trial to hold a virtual conference – i. e. a scientific conference held completely on the Internet and with digital media – which ETH Zurich carried out together with EPFL, the Universities of Zurich and Basel, as well as with Yale, Oxford, Cambridge and Copenhagen Universities in November, was also ultimately geared towards reducing CO_2 emissions by avoiding air travel. A monitoring report on "Sustainable Procurement in Construction" was prepared for the Swiss Federal Council for the first time in 2017.

Coordination tasks

The Federal Government demands compliance with a raft of standards and guidelines in the area of real estate and its operation. The finalising of this is ordinarily done in close collaboration between government agencies, which are commissioned by the Federal Council to take the lead on a particular topic or which are involved in the implementation of standards and guidelines. The Real Estate department, acting on behalf of the ETH Board as the Federal Construction and Properties Service (BLO), performs the task of coordinating the interests of the government agencies and those of the institutions of the ETH Domain and seeks solutions to specific challenges. This work requires it to sit on a wide range of committees, specialist and working groups. They are devoted to issues such as procurement and contracting, sustainable construction, earthquake prevention in government buildings, risk and vulnerability analysis of the research and teaching sub-sector, office for university buildings, and many environmental and energy-related issues. A precondition for successful coordination is the discipline and topic-specific working groups within the ETH Domain and, where necessary, setting up an "echo chamber" for individual questions with representatives from the institutions. In addition to involvement in the permanent committees mentioned, the Real Estate department has also been involved since 2017 in developing the "Strategy for the Building Culture of the Federal Council".

Governance

The ETH Domain has operated an Internal Control System (ICS) for finance-related processes in real estate management since 1 January 2016. It was audited by the Swiss Federal Audit Office (SFAO) in the year under review, encompassing all the organisations concerned – institutions, ETH Board and the Federal Office for Buildings and Logistics (BBL). The results largely confirm the completeness and effectiveness of the ICS, although they have also highlighted areas of potential for the further development of the tool, which is still in its infancy.

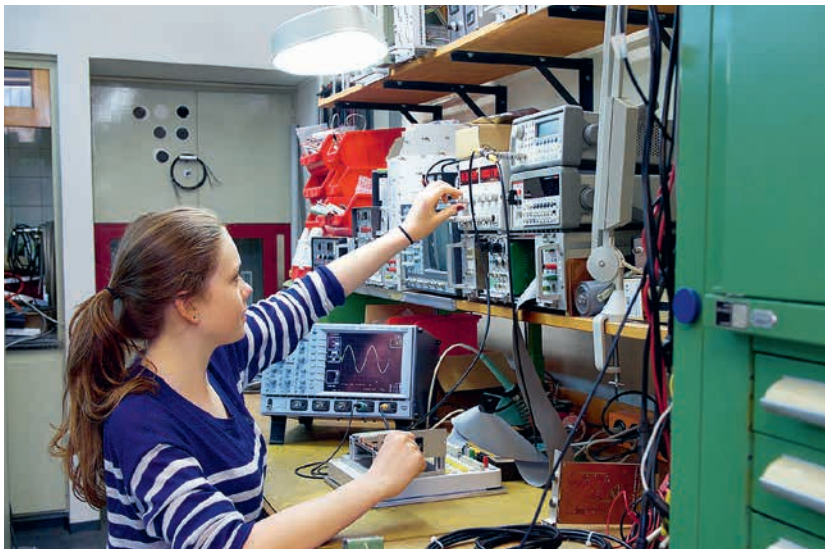
Project work on the ETH Board's management system for real estate-related risks also got under way in 2017. It identifies core risks from the perspective of the owner, which are linked to the extensive and heterogeneous real estate portfolio. The project will be concluded in spring 2018.

The legal basis for this has been created with the revision of the ETH Act with the adaptation to Article 34*b* bis 1, enabling the ETH Domain to place the properties, which are owned by the government, at the temporary use of third parties. The associated regulations state that 50% of the revenue has to be paid over to the Federal Government.

Since 2017, a representative from the ETH Board has been supporting the institutions in their committees on the management of strategic building projects.

10

"The ETH Domain is an attractive and responsible employer."



Over 170 apprentices and interns in 15 career paths have found ideal conditions at ETH Zurich. *(Photo: Heidi Hoststettler/ETH Zurich Vocational Training)*

The ETH Board's perspective

The development of new scientific talent is one of the central factors in the success of the two Federal Insitutes of Technology and the research institutes. Offering the most attractive employment terms possible, they attract the best minds to the ETH Domain. Different development programmes are designed to consolidate the initial and further education of these fledgling scientists, who are not only involved in research, but also in teaching. There has been a rise in the number of development opportunities specifically offered to women, most notably. The proportion of women is to be increased at all levels, in particular in positions of leadership. To that end, the ETH Domain has drawn up a gender strategy which promotes equal opportunity. In order to implement this strategy, the institutions run workshops on gender-related issues, mentoring, coaching and training sessions for women at all levels, and also offer opportunities for childcare during conferences, holiday activities or emergency support. Attractive and family-friendly working conditions are vital to enable women to hold down leading positions in teaching and research.

The institutions of the ETH Domain have an important role to play in the training of apprentices. They offer a variety of teaching posts in the administrative and technical sphere. The apprentices also benefit from the high quality of service provided at the universities and research institutes. The ETH Domain also implements the system of prioritising Swiss nationals for administrative and technical personnel in accordance with the strategic objective set by the Federal Council for the ETH Domain.

Particular measures are also taken by the institutions of the ETH Domain to integrate people from different cultural backgrounds, language regions, age groups and religions. Openness and tolerance are reinforced through internal activities and respect campaigns. The ETH Domain promotes exchange and cooperation and nurtures an open-minded set of world values.

ETH Zurich

ETH Zurich is a preferred training and employment centre for talented people from Switzerland and all around the world. Consequently, the university was crowned the most international university in the world by Times Higher Education (THE). THE identifies ETH Zurich's international orientation as the decisive factor in its success. This enables the university, its students and staff to become best equipped for the global competition.

In this regard, ETH Zurich has taken various measures in its recruitment and personal policy in order to make the most of the domestic recruitment potential in the fields of technology and administration. In particular, it promotes employee mobility within the ETH and gives priority in its appointments to people who are currently employed in Switzerland or who hold Swiss employment permits.

ETH Zurich also lays great store by vocational training. The university is currently training 170 apprentices in fifteen technical and commercial career paths. Fifty-two apprentices and interns successfully completed their apprenticeships or internships in ten different careers in 2017.

ETH Zurich supports the development of its young scientific talent with a broad array of measures. One of its most important programmes is the "ETH Zurich Postdoctoral Fellowship". This is aimed at young postdoc researchers who received their doctorates from neither ETH nor the University of Zurich. A current analysis of the career development of former ETH fellows, who had been selected between 2011 and 2014, shows that 22 people have obtained assistant professorships and two people have obtained full professorships in the meantime (20%).

Senior scientists who are on permanent contracts play an important part in teaching, research and knowledge and technology transfer (KTT) at ETH Zurich. The number of senior scientists is set to be increased in the coming years, roughly corresponding to that of professorships. The duty profiles of senior scientists were analysed and discussed in 2017. A duly differentiated proposal was

submitted for approval in the autumn semester of 2017, and this is set to be implemented in 2018.

As a modern employer and seeking to increase the proportion of women at all levels, ETH Zurich encourages employees to find a work-life balance. Flexible working conditions aid holistic responsibility and employment concept (for instance, Home Office). Parents are supported through the provision of childcare to complement family life, as well as with financial costs. With KihzFlex, ETH Zurich created a scheme in 2017 to enable children to be looked after in the childcare facilities on an hourly or daily basis in the event of unexpected childcare problems arising. Much use is made of this service. Additional funds for the care of infants during conference visits can be provided through contributions from the Robert Gnehm Fund. ETH Zurich gives the ALEA Award (Art of LEAdership Award) to managers who provide their employees with modern and innovative working conditions and who encourage and actively support the reconciliation of work, family and part-time work. This will be replacing the Golden Tricycle after 10 years, which was brought into being in 2007 by the Association of Scientific Staff at ETH Zurich (AVETH) and the Office for Equal Opportunity.

ETH Zurich launched a respect campaign in autumn 2017 in order to set the tone for a culture of cooperation characterised by respect, appreciation, dialogue and trust. It makes it clear that ETH Zurich will not tolerate unreasonable behaviour such as sexual harassment, discrimination, mobbing, violence and threats. In addition, an ETH Zurich-wide code of conduct "Respect" has been prepared, which is to be introduced in early 2018. ■

Since it was established in August 1997, over 100 apprentices have been trained at the Chemistry Laboratory School of EPFL. *(Photo: Alain Herzog/EPFL)*

EPFL

The implementation of the Action Plan for Equal Opportunity from 2017 to 2020 got under way at EPFL in the year under review. The priority fields of action include increasing the number of female professors. During the past three years, women have accounted for between 26 and 30% of assistant professorships with tenure track. This means that EPFL has reached the target of 28% set by the ETH Board for 2016. The recruitment and career strategy for professors based on the tenure track system is a key factor in increasing the number of female associate and full professors. Compared to previous years, there has been a rise in promotions from women in assistant professorial posts to the position of associate professors. Nevertheless, the percentage of women (11%) is below the ETH Board's target of 13%. EPFL has also introduced a specific equal opportunity policy for the professor recruitment process in order to increase the proportion of women among new appointments.

In particular, it will serve to raise awareness among members of appointment committees of the need to take steps to counteract implicit distortions and to mitigate their impact on recruitment processes. Regular workshops are held on this issue, and the chairpersons of appointment committees for professors are required to attend. The conscious efforts to identify a high calibre and diverse pool of candidates, to apply criteria with consistency and to monitor results will also help to ensure that the number of female professors continues to rise.

Various steps have already been taken to promote equal opportunity at new talent level and to improve opportunities for reconciling careers and family life. Since January, doctoral students and postdocs have been entitled to financial support for travel expenses for one person who accompanies them during a conference or a short research visit to look after their infant of 18 months or less. A further new measure is the automatic application of the Stop the Clock system during maternity leave for the length of time of tenure processes is extended to allow for the duration of the maternity leave. An e-learning course on work-life balance is intended to raise awareness among employees of this issue and to provide them with specific tools to reconcile the different areas of their lives more favourably.

2017 was a transitional year for human resources policy at EPFL. The new Senior Management commissioned the newly appointed HR coordinator to start to draw up an HR strategy. The strategy takes account of the EPFL strategy, the legal framework, the objectives of the ETH Board and the needs of employees. It includes the review and adaptation of HR policies and strategies, most notably including those for the scientific staff, as well as consolidating leadership skills, including those of professors.

An online recruitment tool was introduced in the year under review in association with the Vice President for Information Technology Systems. A review of the contractual conditions for administrative and technical employees (fixed-term / permanent) has been successfully completed with a view towards standardising them. ■

The IDCN's event at the PSI. *(Photo: PSI)*

PSI

The success of the PSI depends decisively on the skills, satisfaction, team performance and individual contribution of every single member of staff. Therefore, essential key aspects of human resources policy are the development of young scientific talent and the creation of employment conditions which make it easier for all employees to reconcile their working lives and personal commitments (Ambitious People meet a Friendly Workplace). The primary focus of equality activities at the PSI is to increase the proportion of women at all hierarchical levels, in particular in managerial roles and in decision-making committees. A mentoring programme was drawn up for women who had expressed an interest in taking on a leadership role, and an initial call for applications took place in 2017. In addition to the services available internally within the PSI, doctoral students and postdocs are given the option of taking part in a mentoring pilot project within the scope of the "Fix the Leaky Pipeline!" programme at the ETH Domain, which is intended to assist young women in progressing their careers in science.

The PSI has been a member of the International Dual Career Network (IDCN) since the start of 2017. It provides partners of employees of the affiliated institutions with information about the local labour market and supports them in their efforts to find a job. In order to make foreign employees aware of what is available, the PSI held International Dual Career Day in June 2017 with more than 70 participants.

Managerial staff in the field of science and technology are confronted by ever more complex requirements. To assist these people in their role, PSI is running a specially devised further education course leading to a recognised qualification, the CAS in Leadership in Science, in association with the University of Technology (FHNW Windisch). The course was developed in close collaboration with the other research institutes from the ETH Domain and was run for the first time in September.

In order to make greater use of the opportunities offered by diversity management than was previously the case and to make the PSI's activities in this area more professional, the job of diversity officer was advertised in a joint venture with Eawag, and this post was filled in March 2017. Working together with Human Resources Management and the Committee for Equal Opportunity, she will push ahead with the further development and implementation of the PSI's equal opportunity and diversity strategy. ■

WSL

The development of young scientific talent presupposes support for STEM subjects with the involvement of schools, society, business, universities and research institutions. WSL has rolled out its programmes for younger children, in particular, in previous years. Children of preschool age are regularly introduced the fascinating world of snow, and at the same time to many aspects of natural science, at the SLF in Davos. Several modules for visits by primary school groups were developed and tried out at the headquarters in Birmensdorf in 2017. However, visits by school groups involve a relatively large amount of work both for the schools and for the organisers and are only possible to a limited extent. Therefore, children and teenagers are also a target group in media channels. And so, the specialist website www.wsl-junior.ch has also been redesigned as part of the entire web relaunch. On occasions, research news is even published in age-appropriate language for children. While the video competition for teenagers unfortunately failed to attract the resonance that had been hoped, it still enabled WSL to establish good links with teaching associations and magazines, as well as schools.

At the National Future Day event in Davos and Birmensdorf, WSL provided an insight into research and into the apprenticeships such as being an electronics technician or a chef. The event at the headquarters was not only open to the children and relatives of employees, it was also open to girls who came to the WSL for the *"Mädchen – Technik – los!"* (Girls, Technology, Go) programme.

In the case of men and women who are already working at WSL, internal continuing training in 2017 focused in the theme of "leadership". The theme – and the courses, such as "Having difficult conversations" – is aimed at everyone, and it has been completed by almost one hundred employees. The theory behind the courses with then applied in practice in role-plays, in dialogue with actors, and participants learned a great deal. The programme of courses was rounded off with a world cafe on leadership, on expectations of leadership personnel and employees, as well as on understanding of leadership. ■

WSL trains young people amongst others to be chemistry and biology laboratory assistants, information technology technicians and as factory maintenance operatives (l.). *(Photo: WSL)*

Empa

Empa 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 Balance ZH", the award for "HR Excellence in Research" was received from the European Commission Research and Innovation in 2017.

In the meantime, Empa has also taken appropriate measures to maximise the potential for prioritising Swiss nationals, as a consequence of the implementation of the initiative against mass immigration. The corresponding statutory criteria and recommendations are taken into consideration in the recruitment of new employees. Job vacancies in the administrative and technical fields are advertised on Swiss jobs platforms and reported to the Regional Job Centers (RAV); employment of non-nationals in the administrative and technical fields is excluded without valid grounds. Empa offers assistance in finding a job at the end of the contract (e. g. to apprentices). It is involved in the RAV integration programmes. People with performance restrictions can also fund employment at Empa, enabling them to become integrated into the workplace and developing their employability.

In addition to the annual personal development planning, courses are also offered to doctoral students and postdocs to enable them to plan their own career paths in industry. Long-standing employees can benefit from special courses for developing their own careers. At Empa, specialist careers equate to a career in management and extend as far as Distinguished Senior Researcher level.

Over 40 apprentices are trained at Empa in ten different careers. Every summer, Empa runs a camp for children of primary school age, inspiring an interest at a young age in natural sciences and engineering. Year after year, countless children are also inspired to get involved in science and research at National Future Day. Empa supports the ETH Domain's joint development programme for young female scientists entitled "Fix the leaky pipeline!". The proportion of women in management positions was increased in 2017 both in terms of heads of faculty and heads of department.

Regular training is given on the leadership principles of Empa in management workshops, creating decisive incentives for coherent culture and for active cooperation across departmental and faculty boundaries. All new employees are familiarised with the guidelines governing integrity in research. Both various ombudsman offices and the Human Resources department can support employees and managerial personnel with any questions they may have. ■

Eawag

Eawag is a conscientious employer offering flexible working time models, integrated health management and outstanding continuing training opportunities. The new scientific talent with over 100 doctorate students has the benefit of excellent infrastructure, specific training facilities and information platforms that are geared towards their needs. Eawag offers scientists with fixed-term project appointments workshops for planning their future careers and academic transition grants to develop their qualifications for the labour market. Eawag funds a competitive postdoc fellowship to support talented young researchers. It supports the networking and profile of the research institute sustainably and helps in identifying scientific talent. The "Eawag Partnership Program for Developing Countries" (EPP), which promotes knowledge transfer to students in developing countries, is continuing on an ongoing basis. Eawag trained 27 apprentices in 2017 as chemistry and biology laboratory assistants, commercial personnel and IT specialists.

The Equal Opportunities Committee (EOC) is continuing its dedicated work. The department which was created in associated with the PSI, which also supports Eawag in external committees and with strategic activities, takes responsibility for initiatives, such as the new mentoring services on the "Fix the Leaky Pipeline!" programme. One of the most important themes of the EOC is reconciling family life and a career. The directorate, operates a special "Tailwind" programme to provide young mothers with financial resources to help them during their early months of motherhood. Scientists on a tenure track are given an extension to their employment if they have appropriate family reasons. New fathers can reduce their employment workloads for a limited period of time.

There was a further continuation in the proportion of women in managerial roles (31.3%) thanks to consistent support for this and compliance with internal guidelines. Eawag researcher Kathrin Fenner has been an associate professor ad personam for environmental chemistry at the University of Zurich since 1 February 2017. She is a group leader in the Environmental Chemistry department at Eawag. She is a mother and has enjoyed national and international success in her research (documented i. a. by an ERC Consolidator Grant).

In addition to its commitment to Empa-Eawag childcare facility, Eawag also supports parents who are modest earners by contributing towards childcare costs. Where possible, employees who are ill or disabled with performance restrictions are still integrated into the employment process. ■

Kathrin Fenner, a nationally and internationally successful Eawag scientist. *(Photo: Peter Penicka/Eawag)*

Key figures

The Key figures chapter presents the ETH Domain in facts and figures, in a concise and informative way with some commentary. The detailed account are shown separately in the Financial Report.

31,293
Students and doctoral students

Photo: shutterstock

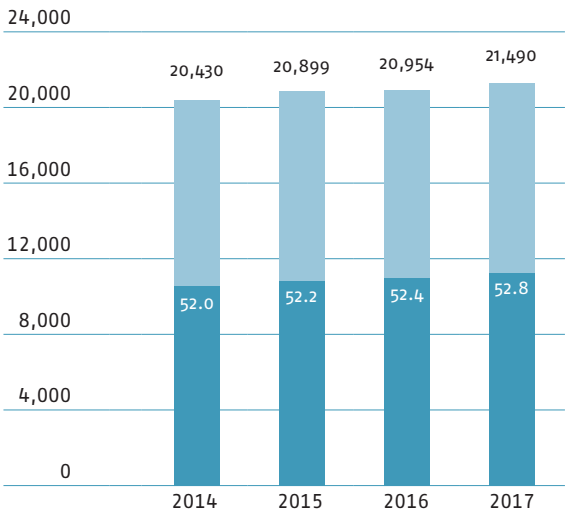
269
ERC grants from 2007 to 2016
in the ETH Domain

3,572
m CHF
Operating income

Financing statement 2017
The Federal Government finances the ETH Domain to the tune of almost 90% (percentage in 2017: 86%). The total federal contribution makes up the main part. Revenues from third-party funds increased again.

It contributes 71%, i. e. the lion's share, directly via its total federal contribution. A further 15%, the Federal Government contributes on a competitive basis via the two promoting organisations SNSF and Innosuisse, via special federal funding of applied research and via funding from EU framework programmes (FP) as research contributions.

Development of employment contracts



Employment contracts (ECs) in the ETH Domain, see fig. 22, p. 101
thereof foreign emplyoyees percentage, see fig. 26, p. 103

Contents

29.5%

Proportion of women appointed as professors

Fig. 6: 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
Teaching				
~~**Undergraduate**~~ **and doctoral students of ETH Zurich and of EPFL** (headcount)				
New admissions				
to the Bachelor's programme[1]	4,052	5,255	5,531	4,756
Students[1]	**16,233**	**22,099**	**24,217**	**25,059**
Percentage who are women	29.3	29.1	29.7	30.6
Percentage who are foreign nationals	27.3	35.5	37.4	38.4
on the Bachelor's programme	10,138	13,995	14,727	14,385
Percentage who are women	28.8	28.6	30.0	30.6
Percentage who are foreign nationals	23.8	30.9	31.6	29.4
on the Master's programme	4,649	7,241	8,662	8,979
Percentage who are women	28.0	29.4	28.5	29.6
Percentage who are foreign nationals	34.4	43.1	46.1	45.9
on the Diploma programme	751	0	0	0
on the MAS/MBA programme	695	863	828	840
Percentage who are women	34.2	34.6	37.9	38.8
Percentage who are foreign nationals	48.1	45.7	50.2	51.5
On a foreign exchange[1]	–	–	–	855
Percentage who are women	–	–	–	33.7
Percentage who are foreign nationals	–	–	–	96.7
Supervision ratio				
Bachelor's/Master's students per professor	25.1	27.7	29.2	28.4
Doctoral students	**4,823**	**5,947**	**6,134**	**6,234**
Percentage who are women	28.6	30.4	31.0	30.8
Percentage who are foreign nationals	62.7	72.6	74.3	75.0
Supervision ratio				
Doctoral students per professor	7.8	7.7	7.7	7.6
Students and doctoral students	**21,056**	**28,046**	**30,351**	**31,293**
Percentage who are women	29.1	29.4	30.0	30.6
Percentage who are foreign nationals	35.4	43.3	44.9	45.7
Supervision ratio				
Students and doctoral students per professor	34.0	36.5	37.9	38.0
Graduations				
Bachelor's degree	1,656	2,249	2,500	2,602
Diploma, Master's degree	1,978	2,663	2,989	3,065
MAS/MBA	336	346	303	394
Doctorate	832	993	1,256	1,258
Teaching and supervision by the research institutions				
Teaching hours	15,569	15,670	18,023	17,992
Bachelor's, Master's and diploma dissertations	391	532	575	602
Doctoral students	700	797	783	807
Percentage who are women	36.1	36.3	39.8	39.0
Percentage enrolled in the ETH Domain	66.1	67.9	67.4	67.7
Percentage enrolled in the ETH Domain	17.3	13.4	11.7	10.3

Indicators	Reference values 2008	2013	2016	Monitoring 2017
Research				
Publications[2]	–	–	–	–
Research contributions, mandates and scientific services[3] (in CHF millions)	–	–	**772.7**	**743.2**
of which, Swiss National Science Foundation (SNSF)	141.6	209.0	257.4	260.3
of which, Innosuisse	26.1	36.8	50.6	62.6
of which, EU Framework Programmes for Research and Innovation (FP)	97.7	135.2	142.1	139.2
Knowledge and technology transfer (KTT)				
Invention disclusre reports[4]	–	–	–	343
Software notifications[4]	–	–	–	26
Patents	125	193	230	206
Licences	178	223	353	297
Spin-offs	46	43	50	48
Personnel (FTE)				
Professors	619.4	767.7	800.8	823.8
Percentage who are women	10.7	12.4	13.9	14.8
Percentage who are foreign nationals	61.8	67.1	68.0	67.2
Scientific personnel	7,956.5	9,927.3	11,053.9	11,204.4
Technical personnel	2,957.6	3,157.3	3,355.1	3,439.8
Administrative personnel	1,771.2	2,279.0	2,577.8	2,690.0
Apprentices	386.0	435.0	463.7	473.6
Finance/real estate				
Total federal contribution (perceived budgetary framework) (in CHF millions)	**1,949.4**	**2,271.4**	**2,453.8**	**2,530.8**
of which, federal financial contribution	1,778.4	2,073.9	2,288.7	2,377.9
of which, investment credit for ETH Domain constructions	170.9	197.5	165.1	152.9

For a description of the counting method, see box on p. 87 and box on p. 93.

[1] Since 2017, exchange students have constituted a separate student category. Prior to then, exchange students had been included in the figures for students at Bachelor's and Master's level. This should be borne in mind when comparing with previous years.
[2] Publishing activity is assessed every four years as part of the intermediate evaluation.
[3] New categories according to IPSAS reporting standards; consequently, 2016 and 2017 figures are not directly comparable with those of previous years.
[4] Additional KTT indicators introduced in 2017.

Growing interest in Information and Communications Technology, as well as Engineering Sciences

The total number of students and doctoral students is increasing significantly in the areas of Information and Communications Technology, and in Engineering Sciences. In view of the general interest of the economy and society in promoting the next generation of scientists in these areas, this development is very welcome.

The number of students and doctoral students at both Federal Institutes of Technology is continuing to increase, and in 2017 reached a total of 31,293 (+3.1%, see fig. 7). Both Federal Institutes of Technology together totalled 14,385 students at Bachelor's level, 8,979 at Master's level, 840 in the MAS/MBA continuing education programmes and 6,234 doctoral students. In 2017, exchange students were counted separately for the first time, giving a total of 855 students.

Developments in teaching

Prior to 2017, exchange students were included in the figures for students at Bachelor's and Master's level (mostly Bachelor's). This should be borne in mind when comparing with the previous year. The decrease in new admissions, and in the total number of students at Bachelor's level, is thus due mainly to exchange students now being counted as a separate group (see fig. 8 and 9). This adjustment also has a direct impact on the staff-student ratio for Bachelor's and Master's degree students (see fig. 12). At doctoral level, student numbers had increased by 1.6% over 2016.

Information and Communication Technology (+7.5%) and Engineering Sciences (+4.1%; see fig. 7) recorded the largest increase in student numbers in the current period. EPFL has been offering Digital Humanities as a new subject at Master's level since 2017. Students who have chosen this subject are included in the figures for Humanities, Social and Political Sciences. With a total of just 380 students (2017), no statistically meaningful statement can be made on its development. ETH Zurich now offers a Bachelor's degree in Human Medicine. As is the case at all universities in German-speaking Switzerland, admission to the Human Medicine course at Bachelor's level is linked to an aptitude test – and ETH Zurich is no exception. The number of new admissions in these disciplines is limited to 100 per year and will remain stable over the years (see fig. 9).

For several years now, both Federal Institutes of Technology have been striving to increase the proportion of women at all levels of study. In 2017 the total share of female students and female doctoral students once again increased slightly, reaching 30.6%. For Bachelor's degree students the proportion of women was 30.6%, for Master's degree students it was 29.6%, and for doctoral students 30.8% (see fig. 10).

A growing number of foreign students and doctoral students are choosing one of the two Federal Institutes of Technology for their studies and they accounted for an increased proportion of the total number (2017: 45.7%; 2016: 44.9%). At Bachelor's level, this was 29.4% of students and at Master's level 45.9%. When comparing these figures with those of previous years, it should be borne in mind that from 2017 these categories no longer include exchange students, of whom more than 95% are of foreign origin. Among the doctoral students, in 2017 the proportion of foreigners was 75%. In the majority of cases, the students and doctoral students from abroad are foreign-educated: 75.6% at Bachelor's level, 91.3% at Master's degree level, and 95.1% at doctoral level (see fig. 11; for definitions, see box on the right).

The staff-student ratio corresponds to the number of students and doctoral students per professor (2017: 38.0; 2016: 37.9). A substantial portion of the supervision activity is also provided by the Senior Scientists and Maîtres d'enseignement (MER) (see box on the right). These staff categories are taken into account when calculating the "extended" staff-student ratio.

PSI, WSL, Empa and Eawag also play a very active role in teaching. Their staff offer courses, seminars and practical workshops and activities, as well as other educational opportunities in various disciplines, for students of both Federal Institutes of Technology, but also for other universities or universities of applied sciences (mostly in Switzerland). In 2017, this commitment was

equivalent to 17,992 teaching hours (see fig. 14). Moreover, these institutes provide a wide range of research topics, mainly in the field of applied research. In 2017, a record 602 students completed their Bachelor's and Master's dissertations, and 807 doctoral students completed their theses, at one of the research institutes.

Indicators and counting methods for the monitoring table and the academic reporting

If not specified in more detail, the term 'students' is always understood to mean Bachelor's and Master's degree students, students in the Master of Advanced Studies and Master of Business Administration (MAS/MBA) continuing education programmes, and exchange 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 courses or levels of study, the prioritised programme or level is counted. Doctoral students, however, are defined as a separate category. Students and doctoral students are included in 'Headcount'. Foreign students and doctoral students form two sub-categories: foreign-educated students of foreign nationality were resident abroad while obtaining the relevant necessary qualifications, and Swiss-educated students of foreign nationality 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 Science Foundation (SNSF) professorships – who are employed at one of the two Federal Institutes of Technology are taken into account in calculating the staff-student ratio. Senior Scientists and Maîtres d'enseignement (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' staff-student ratio, the Senior Scientists and MER are added to the professors of both Federal Institutes of Technology.

The teaching hours delivered by the research institutes do not include preparation time, only the time spent in the presence of students.

Fig. 7: Students and doctoral students by discipline

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Δ 2016/2017	
												in %
Architecture	**2,553**	**2,743**	**2,994**	**3,098**	**3,177**	**3,097**	**3,066**	**3,060**	**3,030**	**3,047**	**17**	**0.6**
ETH Zurich	1,598	1,697	1,848	1,900	1,950	1,852	1,783	1,805	1,771	1,823	52	2.9
EPFL	955	1,046	1,146	1,198	1,227	1,245	1,283	1,255	1,259	1,224	−35	−2.8
Civil and Geomatic Engineering	**1,980**	**2,170**	**2,405**	**2,727**	**2,900**	**3,074**	**2,946**	**2,882**	**2,860**	**2,791**	**−69**	**−2.4**
ETH Zurich	1,141	1,278	1,434	1,576	1,629	1,740	1,731	1,716	1,701	1,688	−13	−0.8
EPFL	839	892	971	1,151	1,271	1,334	1,215	1,166	1,159	1,103	−56	−4.8
Engineering Sciences	**5,081**	**5,597**	**5,985**	**6,391**	**6,816**	**7,245**	**7,502**	**7,903**	**8,069**	**8,398**	**329**	**4.1**
ETH Zurich	3,301	3,677	3,901	4,167	4,341	4,549	4,729	4,930	4,993	5,135	142	2.8
EPFL	1,780	1,920	2,084	2,224	2,475	2,696	2,773	2,973	3,076	3,263	187	6.1
Information and Communications Technology	**1,906**	**1,929**	**2,070**	**2,253**	**2,367**	**2,536**	**2,665**	**2,809**	**3,033**	**3,261**	**228**	**7.5**
ETH Zurich	981	997	1,029	1,082	1,083	1,158	1,247	1,405	1,536	1,753	217	14.1
EPFL	925	932	1,041	1,171	1,284	1,378	1,418	1,404	1,497	1,508	11	0.7
Exact and Natural Sciences	**3,671**	**3,942**	**4,155**	**4,476**	**4,780**	**4,883**	**4,944**	**5,145**	**5,442**	**5,595**	**153**	**2.8**
ETH Zurich	2,271	2,470	2,606	2,790	2,903	2,972	3,024	3,157	3,352	3,505	153	4.6
EPFL	1,400	1,472	1,549	1,686	1,877	1,911	1,920	1,988	2,090	2,090	0	0.0
Human Medicine[1]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**99**	**–**	**–**
ETH Zurich	–	–	–	–	–	–	–	–	–	99	–	–
Life Sciences	**2,858**	**3,034**	**3,176**	**3,314**	**3,708**	**3,879**	**3,990**	**4,051**	**4,216**	**4,312**	**96**	**2.3**
ETH Zurich	2,255	2,391	2,472	2,551	2,823	2,923	3,012	3,044	3,162	3,218	56	1.8
EPFL	603	643	704	763	885	956	978	1,007	1,054	1,094	40	3.8
System-oriented Natural Sciences	**2,030**	**2,104**	**2,205**	**2,261**	**2,201**	**2,159**	**2,211**	**2,284**	**2,411**	**2,437**	**26**	**1.1**
ETH Zurich	2,030	2,104	2,205	2,261	2,201	2,159	2,211	2,284	2,411	2,437	26	1.1
Management, Technology and Economics	**778**	**819**	**859**	**833**	**870**	**897**	**913**	**913**	**972**	**973**	**1**	**0.1**
ETH Zurich	534	562	592	584	583	549	579	582	571	583	12	2.1
EPFL	244	257	267	249	287	348	334	331	401	390	−11	−2.7
Humanities, Social and Political Sciences[2]	**199**	**202**	**255**	**276**	**268**	**276**	**300**	**310**	**318**	**380**	**62**	**19.5**
ETH Zurich	199	202	255	276	268	276	300	310	318	366	48	15.1
EPFL	–	–	–	–	–	–	–	–	–	14	–	–
Total number of students and doctoral students	**21,056**	**22,540**	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**942**	**3.1**
ETH Zurich	14,310	15,378	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	792	4.0
EPFL	6,746	7,162	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	150	1.4
Women	**6,131**	**6,627**	**7,149**	**7,585**	**7,973**	**8,238**	**8,414**	**8,677**	**9,091**	**9,587**	**496**	**5.5**
ETH Zurich	4,345	4,707	5,050	5,292	5,445	5,560	5,701	5,873	6,164	6,563	399	6.5
EPFL	1,786	1,920	2,099	2,293	2,528	2,678	2,713	2,804	2,927	3,024	97	3.3
of which, foreign nationals (all)	**7,453**	**8,396**	**9,488**	**10,456**	**11,437**	**12,152**	**12,354**	**12,804**	**13,615**	**14,290**	**675**	**5.0**
ETH Zurich	4,438	5,113	5,698	6,205	6,559	6,751	6,949	7,226	7,563	7,972	409	5.4
EPFL	3,015	3,283	3,790	4,251	4,878	5,401	5,405	5,578	6,052	6,318	266	4.4

For a description of the counting method, see box on p. 87.
[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. 8: Students and doctoral students by study level

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Δ 2016/2017	Δ 2016/2017 in %
Bachelor's programme	**10,138**	**10,970**	**11,716**	**12,600**	**13,359**	**13,995**	**13,944**	**14,292**	**14,727**	**14,385**	**−342**	**−2.3**
ETH Zurich	6,896	7,344	7,757	8,236	8,468	8,817	8,820	9,087	9,309	9,262	−47	−0.5
EPFL	3,242	3,626	3,959	4,364	4,891	5,178	5,124	5,205	5,418	5,123	−295	−5.4
Master's programme	**4,649**	**5,326**	**5,997**	**6,568**	**6,981**	**7,241**	**7,781**	**8,126**	**8,662**	**8,979**	**317**	**3.7**
ETH Zurich	3,028	3,749	4,281	4,607	4,755	4,811	5,187	5,480	5,861	6,158	297	5.1
EPFL	1,621	1,577	1,716	1,961	2,226	2,430	2,594	2,646	2,801	2,821	20	0.7
Diploma programme	**751**	**395**	**191**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**–**	**–**
ETH Zurich	751	395	191	0	0	0	0	0	0	0	–	–
EPFL	0	0	0	0	0	0	0	0	0	0	–	–
MAS/MBA	**695**	**676**	**792**	**801**	**911**	**863**	**805**	**836**	**828**	**840**	**12**	**1.4**
ETH Zurich	436	502	606	659	763	661	634	640	635	646	11	1.7
EPFL	259	174	186	142	148	202	171	196	193	194	1	0.5
Exchange students	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**855**	**–**	**–**
ETH Zurich	–	–	–	–	–	–	–	–	–	449	–	–
EPFL	–	–	–	–	–	–	–	–	–	406	–	–
Total number of students	**16,233**	**17,367**	**18,696**	**19,969**	**21,251**	**22,099**	**22,530**	**23,254**	**24,217**	**25,059**	**842**	**3.5**
ETH Zurich	11,111	11,990	12,835	13,502	13,986	14,289	14,641	15,207	15,805	16,515	710	4.5
EPFL	5,122	5,377	5,861	6,467	7,265	7,810	7,889	8,047	8,412	8,544	132	1.6
Doctoral programme	**4,823**	**5,173**	**5,408**	**5,660**	**5,836**	**5,947**	**6,007**	**6,103**	**6,134**	**6,234**	**100**	**1.6**
ETH Zurich	3,199	3,388	3,507	3,685	3,795	3,889	3,975	4,026	4,010	4,092	82	2.0
EPFL	1,624	1,785	1,901	1,975	2,041	2,058	2,032	2,077	2,124	2,142	18	0.8
Total number of students and doctoral students	**21,056**	**22,540**	**24,104**	**25,629**	**27,087**	**28,046**	**28,537**	**29,357**	**30,351**	**31,293**	**942**	**3.1**
ETH Zurich	14,310	15,378	16,342	17,187	17,781	18,178	18,616	19,233	19,815	20,607	792	4.0
EPFL	6,746	7,162	7,762	8,442	9,306	9,868	9,921	10,124	10,536	10,686	150	1.4

Exchange students have constituted a separate student category since 2017. Prior to then, exchange students had been included in the figures for students at Bachelor's and Master's level. This should be borne in mind when comparing with previous years. For a description of the counting method, see box on p. 87.

Fig. 9: New admissions to the Bachelor's programme

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Architecture	629	689	671	646	599	604	564	573	569	437
Civil and Geomatic Engineering	459	513	556	638	620	613	486	493	488	366
Engineering Sciences	1,056	1,201	1,183	1,240	1,354	1,429	1,393	1,550	1,518	1,350
Information and Communications Technology	325	396	425	448	465	547	595	596	679	582
Exact and Natural Sciences	787	810	832	954	986	969	952	1,001	1,108	985
Human Medicine[1]	–	–	–	–	–	–	–	–	–	100
Life Sciences	486	523	529	578	700	744	721	695	778	635
System-oriented Natural Sciences	287	276	318	321	336	335	316	366	372	288
Management, Technology and Economics	–	–	–	–	–	–	–	–	–	–
Humanities, Social and Political Sciences	23	18	13	13	12	14	14	16	19	13
Total	**4,052**	**4,426**	**4,527**	**4,838**	**5,072**	**5,255**	**5,041**	**5,290**	**5,531**	**4,756**

Exchange students have constituted a separate student category since 2017. Prior to then, exchange students had been included in the figures for students at Bachelor's and Master's level.This should be borne in mind when comparing with previous years. Management, Technology and Economics does not have a Bachelor's degree course. In Humanities, Social and Political Sciences, there is only one Bachelor's course (for career military officers) and student numbers are low; no statistically relevant statement can be made regarding the trend of new admissions. For a description of the counting method, see box on p. 87.

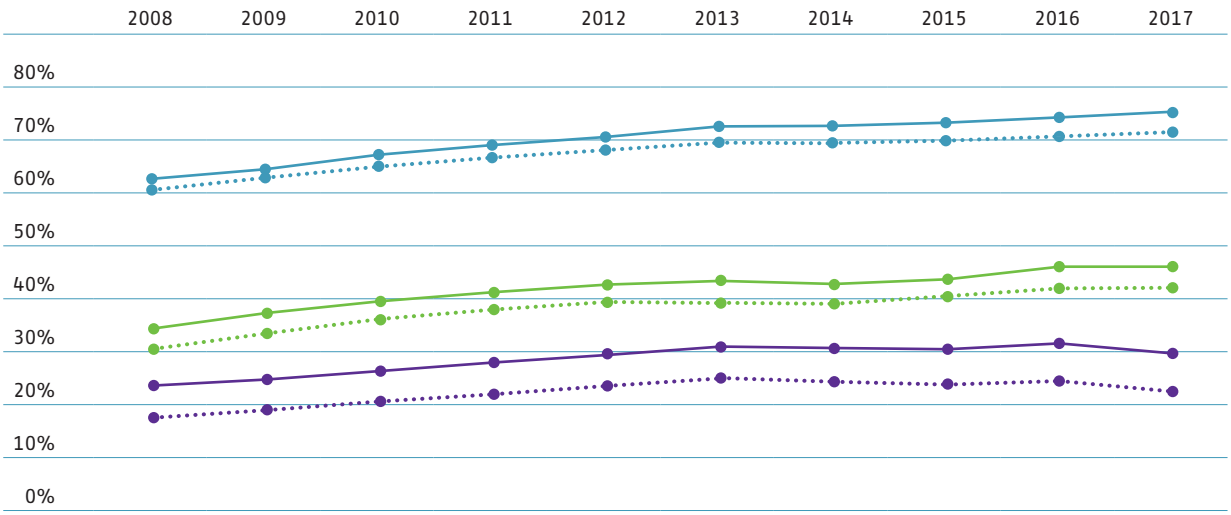
[1] ETH Zurich introduced a Bachelor's degree in Human Medicine in 2017. New admissions in this discipline are limited to 100 and will therefore remain stable over the years.

Fig. 10: Percentage of women among students and doctoral students

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Percentage on the Bachelor's programme	28.8	28.9	28.9	29.4	29.2	28.6	28.7	29.2	30.0	30.6
Percentage on the Master's programme	28.0	29.0	29.2	29.2	28.7	29.4	29.5	28.6	28.5	29.6
Percentage on the MAS/MBA programme	34.2	34.8	37.0	37.1	36.7	34.6	35.0	38.6	37.9	38.8
Percentage who are exchange students	–	–	–	–	–	–	–	–	–	33.7
Percentage on the doctoral programme	28.6	29.3	30.4	29.4	29.8	30.4	30.6	30.6	31.0	30.8

Exchange students have constituted a separate student category since 2017. Prior to then. exchange students had been included in the figures for students at Bachelor's and Master's level. For a description of the counting method, see box on p. 87.

Fig. 11: Percentage of foreign nationals among students and doctoral students



Exchange students have constituted a separate student category since 2017. Prior to then, exchange students had been included in the figures for students at Bachelor's and Master's level. This should be borne in mind when comparing with previous years. For a description of the counting method, see box on p. 87.

Percentage on the doctoral programme:
Total number of foreign nationals
Foreign-educated foreign nationals

Percentage on the Master's programme:
Total number of foreign nationals
Foreign-educated foreign nationals

Percentage on the Bachelor's programme:
Total number of foreign nationals
Foreign-educated foreign nationals

Fig. 12: Supervision ratios at ETH Zurich and EPFL

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Supervision ratio	**34.0**	**34.7**	**35.1**	**35.8**	**36.4**	**36.5**	**36.8**	**37.4**	**37.9**	**38.0**
on the Bachelor's/Master's programme	25.1	25.7	26.1	26.8	27.3	27.7	28.0	28.6	29.2	28.4
on the doctoral programme	7.8	8.0	7.9	7.9	7.8	7.7	7.8	7.8	7.7	7.6
Extended supervision ratio	**21.9**	**22.4**	**22.9**	**23.7**	**24.5**	**24.7**	**24.7**	**25.3**	**25.7**	**25.8**
on the Bachelor's/Master's programme	16.1	16.6	17.0	17.8	18.4	18.7	18.8	19.3	19.8	19.2
on the doctoral programme	5.0	5.1	5.1	5.2	5.3	5.2	5.2	5.3	5.2	5.1

Exchange students have constituted a separate student category since 2017. Prior to then, exchange students had been included in the figures for students at Bachelor's and Master's level.This should be borne in mind when comparing with previous years. For a description of the counting method and for the definition of staff-student ratio and extended staff-student ratio, see box on p. 87.

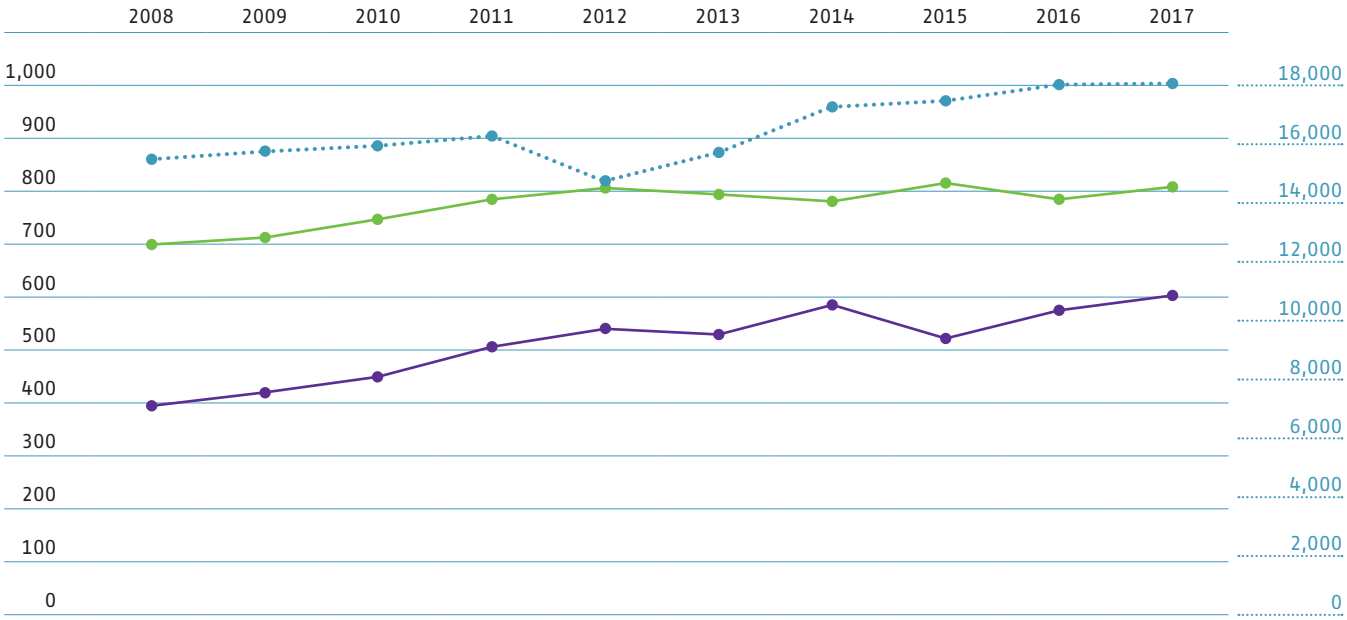
Fig. 13: Degrees awarded by study level

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Δ 2016/2017	
												in %
Bachelor's	**1,656**	**1,835**	**1,900**	**1,988**	**2,216**	**2,249**	**2,538**	**2,528**	**2,500**	**2,602**	**102**	**4.1**
ETH Zurich	1,086	1,203	1,283	1,304	1,447	1,447	1,579	1,564	1,571	1,606	35	2.2
EPFL	570	632	617	684	769	802	959	964	929	996	67	7.2
Master's/diploma	**1,978**	**1,988**	**1,898**	**2,159**	**2,320**	**2,663**	**2,711**	**2,821**	**2,989**	**3,065**	**76**	**2.5**
ETH Zurich	1,306	1,317	1,270	1,506	1,650	1,847	1,839	1,879	2,015	2,072	57	2.8
EPFL	672	671	628	653	670	816	872	942	974	993	19	2.0
MAS/MBA	**336**	**400**	**283**	**301**	**256**	**346**	**260**	**254**	**303**	**394**	**91**	**30.0**
ETH Zurich	213	239	174	203	184	228	205	175	203	272	69	34.0
EPFL	123	161	109	98	72	118	55	79	100	122	22	22.0
Doctorate	**832**	**962**	**986**	**1,027**	**1,095**	**993***	**1,197***	**1,109**	**1,256**	**1,258**	**2**	**0.2**
ETH Zurich	566	651	650	696	747	579	769	718	851	827	– 24	– 2.8
EPFL	266	311	336	331	348	414	428	391	405	431	26	6.4

For a description of the counting method, see box on p. 87.

* In the context of the revision of ETH Zurich's doctoral regulations, the last doctoral graduation deadline of 2013 was deferred from December 2013 to January 2014. This explains the marked increase in doctoral students in 2014 to 1,197. Without this change, 1,022 doctoral students would have graduated.

Fig. 14: 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 dissertations
Number of teaching hours per annum

Knowledge and technology transfer

The knowledge and technology transfer (KTT) offered by the ETH Domain is a key component for the success of an innovative Switzerland. The ETH Domain also made a significant contribution to this in the current period thanks to 343 invention disclosure reports and 26 software notifications, as well as 206 patents and 297 licences. It encourages the formation of spin-offs and promotes their success by supporting them during the foundation phase with various services provided by the institutions. 48 spin-offs were founded in the ETH Domain in 2017. The institutions also work directly with private enterprise and the public sector. In concrete terms, the institutions of the ETH Domain entered into 507 new cooperation agreements with a volume of more than CHF 50,000 per contract with private enterprise and 285 with the public sector. As of 2017, invention disclosure reports, software notifications and cooperation agreements, are listed as additional KTT indicators in order to more fully reflect the innovation contribution of the ETH Domain. In fact, students and doctoral students who do their research work with industrial partners or businesses also lend support to this contribution. In addition, the Swiss economy and society ultimately benefit from the expertise of the graduates.

Fig. 15: Knowledge and technology transfer in the ETH Domain

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Invention disclosure reports	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**343**
ETH Zurich	–	–	–	–	–	–	–	–	–	171
EPFL	–	–	–	–	–	–	–	–	–	134
Research institutes	–	–	–	–	–	–	–	–	–	38
Software notifications	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**26**
ETH Zurich	–	–	–	–	–	–	–	–	–	20
EPFL	–	–	–	–	–	–	–	–	–	6
Research institutes	–	–	–	–	–	–	–	–	–	0
Patents	**125**	**155**	**128**	**147**	**195**	**193**	**211**	**219**	**230**	**206**
ETH Zurich	64	78	63	72	87	103	82	98	109	84
EPFL	40	44	47	52	75	66	99	88	100	95
Research institutes	21	33	18	23	33	24	30	33	21	27
Licences	**178**	**176**	**178**	**194**	**230**	**223**	**270**	**311**	**353**	**297**
ETH Zurich	48	37	39	45	35	38	35	50	78	82
EPFL	29	47	45	50	31	41	46	48	58	50
Research institutes	101	92	94	99	164	144	189	213	217	165
Spin-offs	**46**	**45**	**38**	**40**	**38**	**43**	**49**	**48**	**50**	**48**
ETH Zurich	23	24	20	22	22	24	22	25	25	25
EPFL	18	20	14	15	12	12	24	18	20	15
Research institutes	5	1	4	3	4	7	3	5	5	8

As of 2017, invention disclosure reports and software notifications are listed as additional KTT indicators.

KTT indicators and counting methods

The patents correspond only to priority applications, and the licences also include technology transfer agreements. The invention disclosure reports 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 at home 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.

343 Invention disclosure reports

26 Software notifications

206 Patents

297 Licences

48 Spin-offs

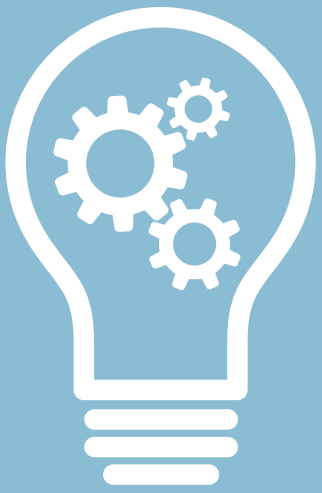


Fig. 16: Cooperation with the private and public sectors

	2017
Cooperation agreements with the private sector	**507**
Financed by the private sector	**316**
ETH Zurich	122
EPFL	99
Research institutes	95
Financed by Innosuisse/FP*	**191**
ETH Zurich	57
EPFL	66
Research institutes	68
Cooperation agreements with the public sector	**285**
ETH Zurich	88
EPFL	54
Research institutes	143

Number of new cooperation agreements (research agreements and scientific services) with the private and the public sector with a volume of at least CHF 50,000 per contract. These indicators are shown as of 2017. For a description of the counting method, see box above.

* FP: EU Framework Programmes for Research and Innovation

Top grades in an international comparison

ETH Zurich and EPFL have confirmed their standing among the world's leading universities. Switzerland is ranked fifth in successful bidding for ERC grants. More than half of those grants were awarded to researchers from the ETH Domain. This success was also aided by the excellent economic and political conditions.

The institutions of the ETH Domain continually monitor the quality and further development of their teaching, research, knowledge and technology transfer, research infrastructure, and management. For this, each institution compares its selected concepts, methodology, tools and processes in these areas with those of other institutions. This process of benchmarking is an important aspect of quality management in the ETH Domain. Efforts are made here to ensure that benchmarking is appropriately selective, that the parameters used are carefully chosen and are relevant to the institutions being compared, and that the findings are interpreted within the right context.

Benchmarking activities

Fig. 17 shows the analytical activities of the institutions of the ETH Domain which can be used for benchmarking. The activities complement each other, and mainly serve the purposes of organisational and strategic development, as well as ensuring that the strategic targets set by the Federal Council are met. The activities aimed at organisational and strategic development (e.g. evaluations and audits) call for an honest appraisal by the institution and ETH Domain of their own strengths and weaknesses, and require a confidential framework to ensure objectivity and provide genuine benefit. The qualitative findings aid the further development of scientific excellence at the institutions.

In addition to benchmarking activities under the remit of the institutions, benchmarking is also performed by third parties (such as companies or university institutes). They make use of publicly accessible information and compare institutions or their entities based on certain indicators or key performance data. The institutions included in this kind of benchmarking have little or no influence on the choice and weighting, and thus on the relevance, of the indicators. Examples are the international university rankings.

Selected benchmarking examples

Some selected examples, which are examined more closely due to their topical relevance, show the international standing of the institutions in a specific field. They only represent a small sample of the activities. ETH Zurich and EPFL's current positions in the international university rankings are shown, along with the progression of their standings over the past ten years (see p. 96). The ERC grants acquired for the entire ETH Domain are shown from their introduction in 2007 through to 2016 inclusive. The number of ERC grants acquired by researchers at institutions in Switzerland is shown in comparison to the ten most successful countries in Europe. In addition, the proportion of ERC grants acquired by researchers from the institutions of the ETH Domain is shown as a proportion of the total number of grants acquired in Switzerland (see p. 99).

Fig. 17: Benchmarking activities in the ETH Domain

Evaluations by external experts (peer reviews)
- ETH Domain (intermediate evaluation by the EAER)
- ETH Zurich departments
- EPFL schools
- Research and administrative units of both Federal Institutes of Technology
- Research institutes (or their units)

Audits and accreditation
- Internal audits (as part of "horizontal audits")
- External audits (e. g. by the Swiss Federal Audit Office, SFAO)
- Institutional accreditation of both Federal Institutes of Technology under the Higher Education Funding and Coordination Act (HEdA)
- Accreditation of Master's degree programmes at EPFL by the French Commission des Titres d'Ingénieur (CTI)
- Accreditation by the Swiss accreditation body (testing, inspection, calibration and certification bodies)

Benchmarking in teaching
- Curriculum development and student support services in collaboration with leading international universities (IDEA League, IARU, EuroTech Universities)

Surveys of
- Staff on how satisfied they are with their working conditions
- Students on how satisfied they are with their study conditions
- Students on teaching (course evaluation)
- Graduates on completion of the course (internally and by the Federal Statistical Office, FSO)

Appointment and promotion procedures for professors based on international job advertisements and recommendations

Research infrastructure
Availability, use and performance of research infrastructure

Acquisition of competitive research funding
at national and international level (for instance, SNSF, Innosuisse, EU Research Framework Programmes)
→ *see "Ten years of ERC grants", p. 99 f.*

Publications and citations
- Bibliometric analyses (for instance, for all the institutions of the ETH Domain within the scope of the interim evaluation)
- Comparisons of selected bibliometric indicators

International university rankings
Worldwide, regional and by subject areas
→ *see "University rankings of ETH Zurich and EPFL", p. 96 f.*

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 Ranking of 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 (fig. 18) are based on this indicator.

Fig. 18: Rankings of ETH Zurich (blue) and EPFL (green) according to the THE, QS, ARWU and CWTS Leiden Rankings in 2017/2018

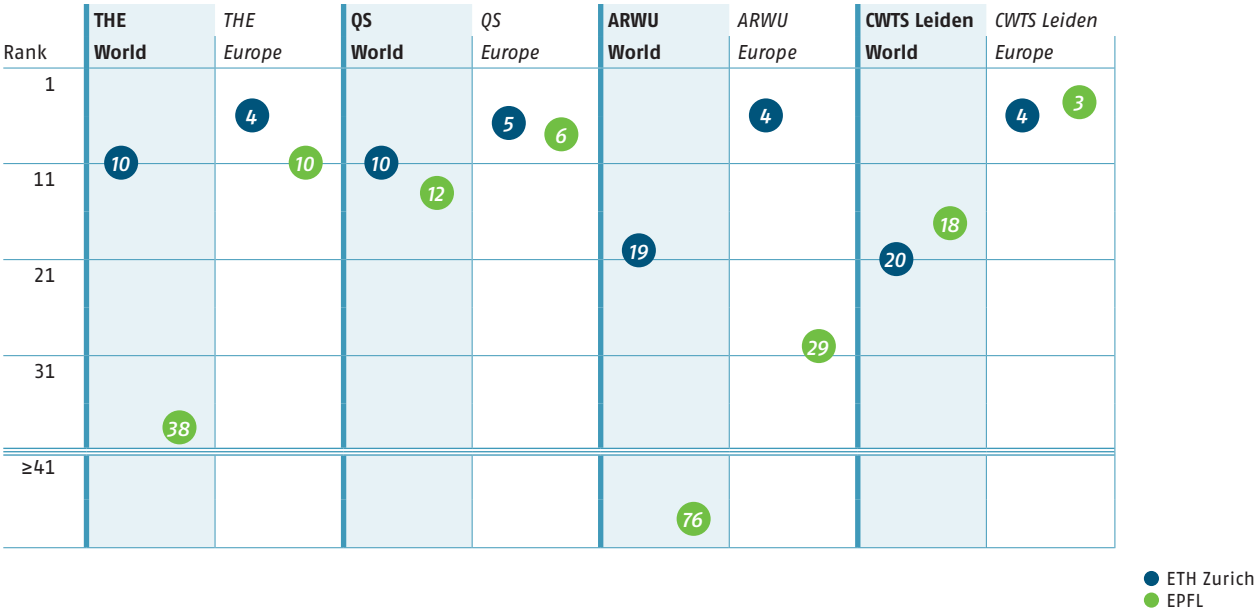
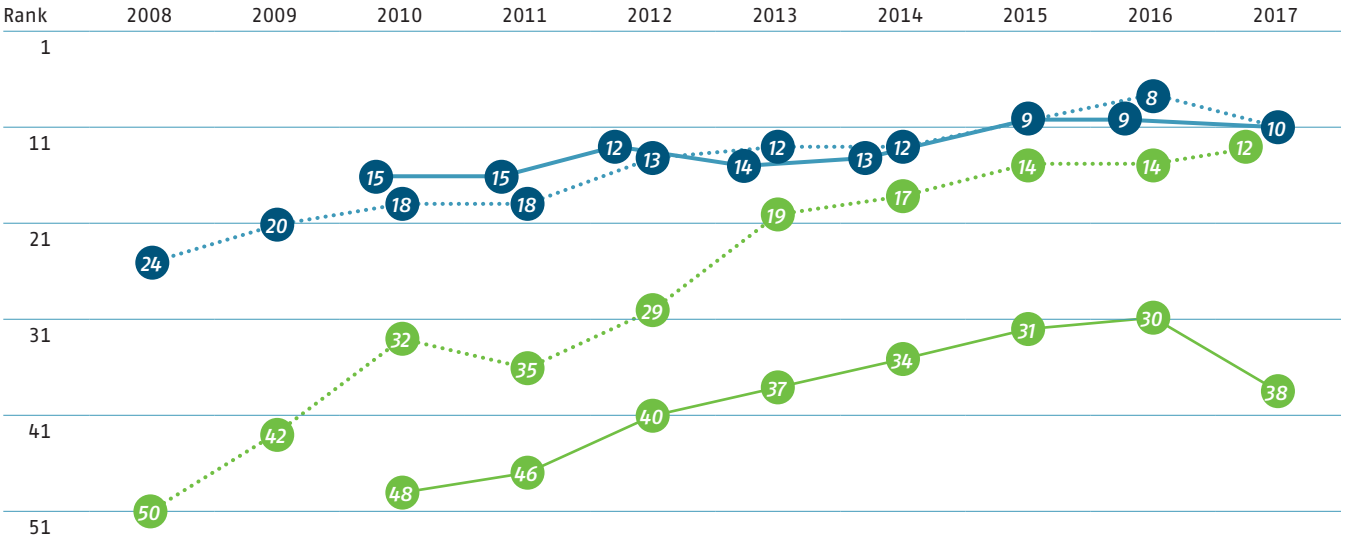


Fig. 19: Rankings of ETH Zurich (blue) and EPFL (green) according to the THE and QS World Rankings from 2008 to 2017



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%)) (see box on p. 95)

THE World Ranking ETH Zurich
THE World Ranking EPFL
QS World Ranking ETH Zurich
QS World Ranking EPFL

University rankings

The companies and institutions which are responsible for the international rankings of universities assess them on the basis of data on teaching, research, publishing activity, international networking and funding. This is done with publicly accessible data and, in some cases, with data which is specially collected. The rankings vary depending on the key performance indicators used and their weighting, each with a specific focus. This is used as a basis for ranking the universities worldwide, in certain regions or specific disciplines. The selection and weighting of the key performance indicators for four selected rankings of worldwide repute are briefly described (see box on p. 95), and the positions of both Federal Institutes of Technology published in 2017 are shown in a worldwide and European comparison (see fig. 18).

In the THE World Ranking, ETH Zurich moved up into the top ten universities in the world for the first time in 2015 and has held its place there since then (10th in 2017). EPFL managed to improve its ranking to 30th place each year until 2016 and was ranked 38th in 2017. In a comparison of European universities (THE Europe), ETH Zurich stayed in 4th place in 2017, the same as the previous year. Positions 1 to 3 are occupied by universities in England. EPFL remained among Europe's top ten universities, ranked in 10th place, in 2017 (9th in 2016). In the THE Rankings of universities which were founded in the past 50 years (THE "Young University Ranking"), EPFL was ranked in 1st place in 2017 (not shown) for the third time in a row.

ETH Zurich also moved into the top ten for the first time in the QS World Ranking in 2015 and has managed to remain there (10th in 2017). EPFL managed to increase its ranking and was in 12th place in 2017 (14th in 2016). ETH Zurich is ranked in 5th place among European universities (4th in 2016), and EPFL is ranked 6th, unchanged from the previous year. Both Federal Institutes of Technology are surpassed only by universities in England.

As in 2016, ETH Zurich is ranked 19th in the ARWU World Ranking. EPFL improved its ranking and was in 76th place in 2017 (92nd in 2016). In a European comparison, ETH Zurich remained in 4th place, and EPFL came 29th (30th in 2016).

In the CWTS Leiden Ranking, which is based solely on the publication activity of the universities, ETH Zurich improved slightly in the global comparison, ranked in 20th place (23rd in 2016). EPFL is ranked two places higher at 18th, although it is down on the previous year (12th in 2016). The two Federal Institutes of Technology are in adjacent places in a European comparison, with EPFL ranked third (2nd in 2016), and ETH Zurich in 4th place, unchanged from the previous year. Ahead of the two Federal Institutes of Technology are two universities in England.

University rankings are an easy way of obtaining an initial impression of how a university compares internationally. The changes in the rankings of both Federal Institutes of Technology in the worldwide THE and QS rankings reflect a trend that complements the assessment of the annual rankings in isolation (see fig. 19). Both views should be interpreted with caution because, firstly, the information they reveal is limited and, secondly, the methodology and key performance data are subject to change, and their comparability over time is limited.

Ten years of ERC grants: a success story for Europe, Switzerland and the ETH Domain

The European Research Council (ERC) started work in 2007 and has been funding basic research in Europe since then by awarding ERC grants. The awarding is an extremely competitive process and is based solely on the scientific excellence of the project proposals that are submitted. The grants come with substantial financial resources and boost the international reputations of the researchers and of the institutions where the research is carried out. Over the ten years, more than 7,000 researchers have been awarded ERC grants from a total funding pool of around EUR 12bn. An evaluation of the projects which were made possible and completed thanks to those grants has revealed that many of them have led to significant or even ground-breaking scientific findings.

Researchers at institutions in Switzerland have been very successful in their bids for ERC grant funding since 2007 and had managed to secure a total of 530 ERC grants by 2016. This makes Switzerland the fifth most successful country, after the United Kingdom, Germany, France and the Netherlands (see fig. 20). If the number of grants was gauged on a per capita basis, Switzerland would even come out on top.

The ETH Domain accounted for over half of the ERC grants that were acquired by researchers at institutions in Switzerland (see fig. 21). These 269 ERC grants were made up of 98 Starting, 27 Consolidator, 116 Advanced, and 28 Proof of Concept Grants.

In addition to the ERC grants, 8 Starting and 10 Consolidator Grants were also acquired in 2014 as part of the Temporary Backup Schemes operated by the Swiss National Science Foundation (SNSF). The economic and political conditions, the various opportunities for cooperation in the ETH Domain and access to outstanding research infrastructures, which provide a platform for the development of competitive project proposals and the successful execution of the projects, played a significant part in the excellent results achieved by the ETH Domain.

The institutions have been successful once again in 2017 and have acquired 9 Starting, 10 Consolidator and 3 Proof of Concept Grants. Further information and examples relating to the institutions can be found in the report on the attainment of targets in the chapter on "Strategic targets".

ERC grants from the European Research Council

Depending on how far the researchers have progressed in their careers, the following grants are available: "ERC Starting Grants" of up to EUR 1.5m for five years for researchers at an early stage in their careers, "ERC Consolidator Grants" up to EUR 2m for five years to set up a separate research group, "ERC Advanced Grants" of up to EUR 2.5m for five years for established researchers who are leading figures in their field, "ERC Proof of Concept Grants" of up to EUR 150,000 for 18 months to translate research findings into commercial or social applications for researchers who have already received an ERC grant; "ERC Synergy Grants" of up to EUR 10m for six years for a joint project with two to four lead researchers who may be affiliated to different institutions. ERC Synergy Grants were awarded in 2012 and 2013 and are being readvertised for 2018.

Eligible applicants for ERC grants are scientists of all nationalities who conduct their research at institutions in EU member states or in associated countries. Due to its decision to adopt the mass immigration initiative on 9 February 2014, Switzerland was temporarily excluded from the Horizon 2020 Research Framework Programme, and researchers at institutions in Switzerland were unable to apply for the ERC Starting and Consolidator Grants in 2014. Partial association within Horizon 2020 became possible from 15 September 2014, giving researchers access to ERC grants once again. The Temporary Backup Schemes operated by the SNSF enabled the temporary exclusion to be bridged. The grants in the Temporary Backup Schemes are not included in figures 20 and 21, but are mentioned in the text.

[1] erc.europa.eu/sites/default/files/qualitative_evaluation_of_completed_projects_funded_by_the_erc.pdf

Fig. 20: The ten most successful countries at acquiring ERC grants from 2007 to 2016

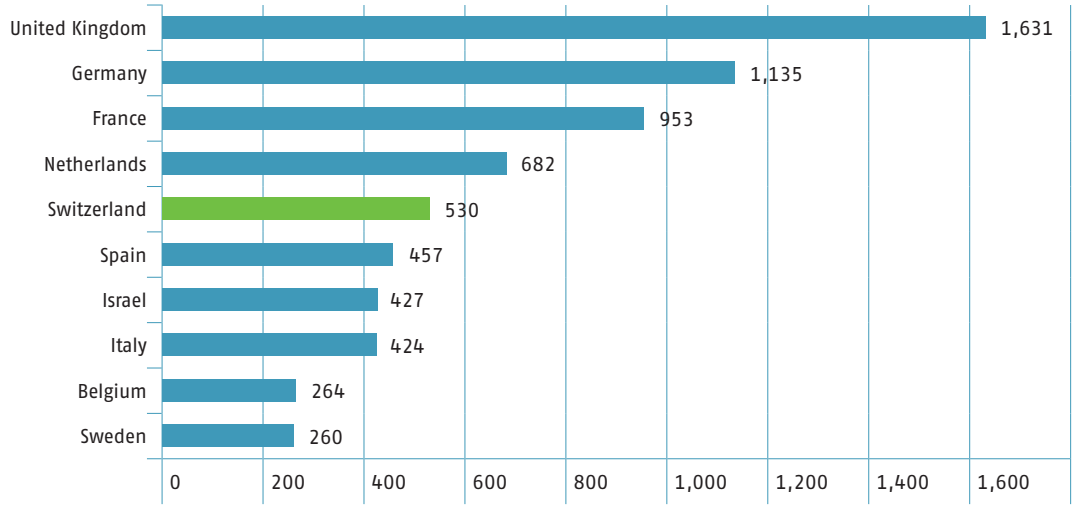
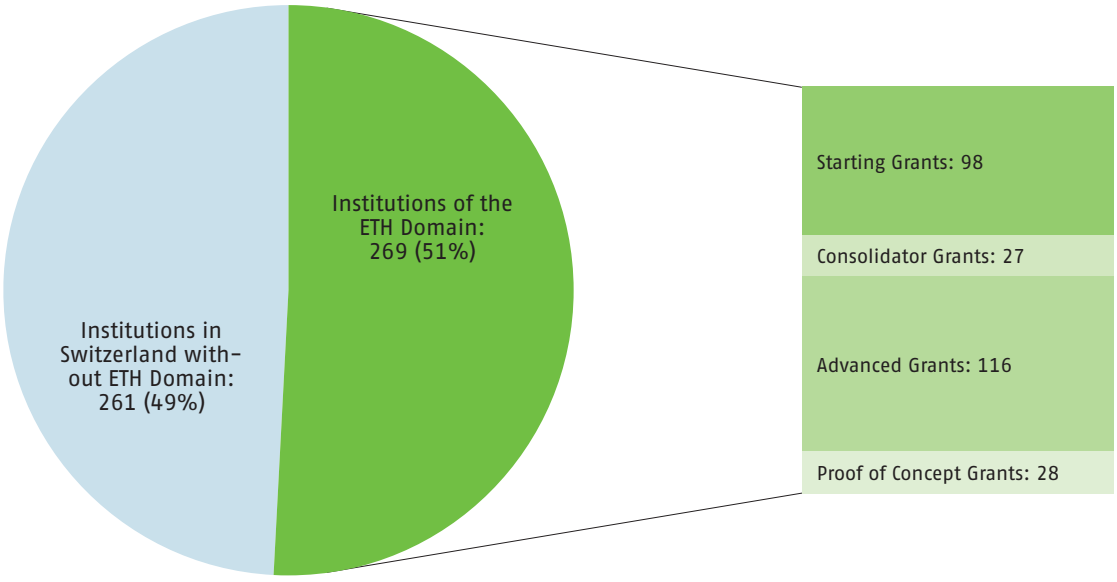


Fig. 21: ERC grants received by researchers at institutions in Switzerland from 2007 to 2016 – ETH Domain's share



The data are based on figures quoted on the website erc.europa.eu/projects-figures/erc-funded-projects (as of 30 October 2017) and include all the funding schemes from 2007 to 2016. The allocation of grants to institutions is based on the date when the contract is concluded. Grants awarded to researchers at CERN (13 in all) are allocated to Switzerland according to the website and are counted accordingly.

Stable growth in staff numbers, proportion of women increased again

The proportion of women reached 34% for the first time, which is the highest ever. Personnel growth is 2.1% lower than in recent years. The scientific staff remains the largest functional group.

On 31 December 2017, the headcount in the ETH Domain stood at 21,490 employment contracts (ECs), or 18,631.6 full-time equivalents (FTEs) (2016: 21,054 ECs or 18,255.9 FTEs) (see fig. 22). While the rise in staffing figures of 436 ECs (+2.1%)[1] was a little higher than in 2016, it was in the lower range of previous growth rates, which were between around 2 and 3%. During the reporting year, 375.7[2] additional FTEs were created (2016: 187.3 FTEs). In comparison with 2016, the greatest growth was among scientific personnel with 205 or 47.0% additional ECs (2016: 34 or 21.9%); followed by administrative personnel with 128 (2016: 75) additional ECs. The group of technical employees increased by 72 or 16.5% (2016: 22). The proportion of Senior Scientists, maîtres d'enseignement et de recherche (MER) and senior scientific personnel was 3.7% of the total staff (2016: 3.8%).

Scientific personnel, accounting for 12,970 ECs or 60.4%, including doctoral students, were still clearly the largest function group in the ETH Domain (2016: 12,765 or 60.6%) (see fig. 22). The ETH offered 474 (2016: 464) young people one of the popular apprenticeships in basic vocational education.

Of the additional 365.83 (2016: 176.6) FTEs (without apprentices) created in 2017, 128.3 were funded by the federal financial contribution. This represents a share of 35% (2016: 88.4%). The other 237.4 FTEs or 65% were funded by third-party resources (2016: 16%) (see fig. 28).

Professors

In 2017, ETH Zurich and EPFL had a total of 686 full professors (F) and associate professors (A) (2016: 669), as well as 109 assistant professors with tenure track (TT) (2016: 109) and 55 assistant professors without TT (2016: 51) (see fig. 23).

The total number of female F and A professors rose by 11 to 88, which represents an increase of 14.3%. The proportion of women in the three categories (see box on right) grew from 13.9% to 14.9% in 2017. Among the F and A professors, the proportion of women was 12.8% (2016: 11.5 %), among assistant professors with TT it was 22.0% (2016: 22.0%) and 27.3% among assistant professors without TT (2016: 27.5%).

In 2017, 452.5 FTEs of the 514 professorships (500.6 FTEs) at ETH Zurich, were financed by the total federal contribution, 22.9 FTEs with funding from the Federal Government (SNSF), 3.7 FTEs with EU research programme funding, and 21.5 FTEs with third-party research contributions, donations and bequests. Of the 336 professorships (322.9 FTEs) at EPFL, 304.2 FTEs were financed by the total federal contribution, 8.6 FTEs by SNSF, and 0.2 FTEs by EU research programmes, and 9.9 FTEs from donations and bequests.

In 2017, 66.9 % of the total of 850 professors came from abroad (2016: 67.6%). Of these 53.3% (2016: 54%) came from the EU area, and 13.6% from other countries (see fig. 24). 66.7% of the new staff appointed in all

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, regulating the framework conditions for the appointment of the affiliated professors, who are appointed directly and are primarily engaged in research. 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.

[1] Growth in personnel in 2016: 155 ECs or +0.7%; 2015: 469 ECs or +2.3%; 2014: 553 or 2.8%.
[2] The 375.7 full-time equivalents (FTEs) created in the reporting year also include the 9.9 FTEs of the ten newly created apprenticeship places. The Source of Funds table (fig. 28) shows the full-time equivalents (FTEs) excluding apprentices.

professorial categories are EU citizens (2016: 60%) and 11.1% are from Switzerland (2016: 8.9%); 22.2% of the new arrivals (2016: 31.1%) come from other countries. 77.8% of the 27 new professors were male (2016: 91.1%) and 22.2% were female (2016: 8.9%).

Proportion of women

At the end of 2017, the proportion of women in the ETH Domain reached the 34% mark for the first time: the ratio of women to men in total staffing had remained just below that figure in recent years (2016: 33.6% vs. 66.4%). The proportion rose in practically all institutions, and the increase at the end of 2017 amounted to 3.2% (2016: +0.92%). The number of women employed in the ETH Domain increased by 223 (2016: 65), accounting for a total of 7,301 employment contracts as of the end of 2017. The proportions vary according to discipline and institution. The lowest proportions of women are at PSI and Empa; the highest are at Eawag (see fig. 27). The number of women professors in the reporting year rose significantly because of the large number of nominations of women (see p. 103).

Apprentices

The ETH Domain offered 474 apprentices an apprenticeship in more than twenty different professions. The focus of the apprenticeships offered is on the scientific/technical professions. The most popular disciplines are chemistry lab technician, IT specialist, commercial assistant, multi-skilled mechanic, physics lab technician, followed by biology lab assistant and electronics technician. As of the end of 2017, the number of apprenticeships for young people had increased from 344 to the current figure of 474 since 2003 (2016: 464). The proportion of female apprentices did not rise any further in 2017 and now stands at 31% (2016: 31.7%).

Heterogeneity – Origins of personnel

The high level of internationalisation in the ETH Domain is also reflected in the origins of employees. Foreign nationals accounted for 52.8% of all employees in 2017 (2016: 52.4%) (see fig. 26).

As to the representation of linguistic communities, see fig. 25.

Potential to recruit Swiss employees

The institutions of the ETH Domain have taken measures in their recruitment and human resources policy to exhaust the potential to recruit Swiss employees in the

Practical, basic vocational education at PSI

"Is it possible to work here without having done a degree?" This is a question that is frequently asked. The answer is "yes". In order to be among the best, the PSI is also dependent upon highly skilled people from vocational backgrounds. The PSI is currently training around 100 apprentices to become specialists in 15 different occupations. They include Delia Schüpbach (left), who is in the second year of her apprenticeship as a physics laboratory assistant. In 2017 she worked in the research group for fuel cell systems and optimised a computer program for wiring a fuel cell test stand. It is hoped that the fuel cells developed at the PSI will ultimately lead to vehicles which generate absolutely no CO_2 emissions. She uses the oscilloscope to measure a time sequence of electrical voltages. "I really enjoy being involved in new developments from the idea through to realisation and being able to contribute towards practical technical solutions."

Fig. 22: Headcount and employment level by function group

	Men			Women			ETH Domain		
2017	EC	FT	ø EL %	EC	FT	ø EL %	EC	FT	ø EL %
Professors (F/A)	598	577.8	96.6	88	83.7	95.1	686	661.5	96.4
Assistant professors with tenure track	85	85.0	100.0	24	24.0	100.0	109	109.0	100.0
Assistant professors without tenure track	40	39.2	98.0	15	14.1	94.0	55	53.3	96.9
Scientific personnel	9,082	7,982.8	87.9	3,888	3,221.6	82.9	12,970	11,204.4	86.4
of whom senior scientific personnel	682	654.2	95.9	108	96.4	89.3	790	750.6	95.0
Technical personnel	2,926	2,766.9	94.6	872	672.9	77.2	3,798	3,439.8	90.6
Administrative personnel	1,131	986.9	87.3	2,267	1,703.1	75.1	3,398	2,690.0	79.2
Apprentices	327	326.6	99.9	147	147.0	100.0	474	473.6	99.9
Total	**14,189**	**12,765.2**	**90.0**	**7,301**	**5,866.4**	**80.4**	**21,490**	**18,631.6**	**86.7**

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 6,234 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.

Fig. 23: Development in the numbers of female and male professors

	2016			2017			Changes		
2017	Men	Women	Total	Men	Women	Total	Men in %	Women in %	Total in %
Professors (F/A)	592	77	669	598	88	686	1.0	14.3	2.5
Assistant professors with tenure track	85	24	109	85	24	109	0.0	0.0	0.0
Assistant professors without tenure track	37	14	51	40	15	55	8.1	7.1	7.8
Total professors	**714**	**115**	**829**	**723**	**127**	**850**	**1.3**	**10.4**	**2.5**

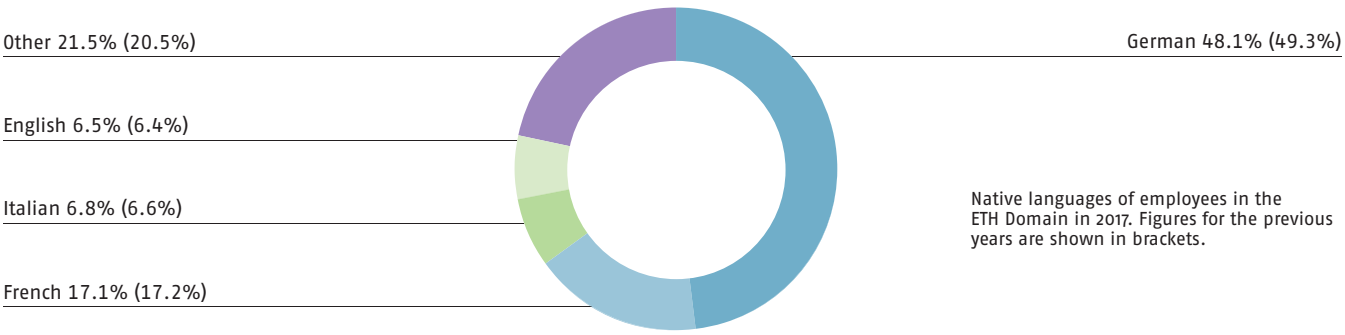
Change in the number of professors according to full and associate professors, assistant professors with tenure track and assistant professors without tenure track. The three last columns show the percentage change since the previous year.

Fig. 24: Origin of male and female professors

	Switzerland			EU			Other		
2017	Men	Women	Total	Men	Women	Total	Men	Women	Total
Professors (F/A)	221	26	247	306	52	358	71	10	81
Assistant professors with tenure track	13	5	18	49	13	62	23	6	29
Assistant professors without tenure track	13	3	16	22	11	33	5	1	6
Total professors	**247**	**34**	**281**	**377**	**76**	**453**	**99**	**17**	**116**

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

Fig. 25: Employees' native languages



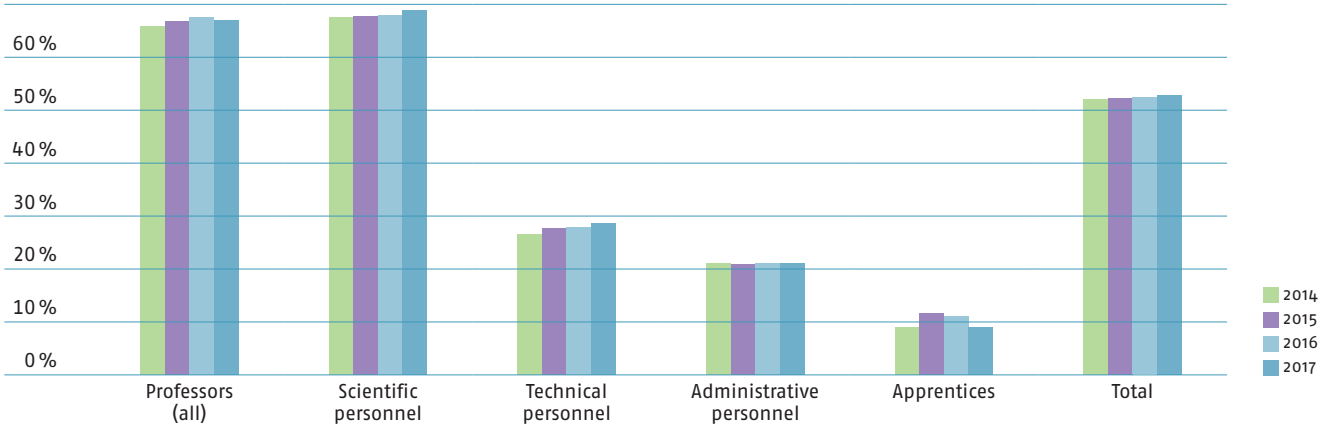
Native languages of employees in the ETH Domain in 2017. Figures for the previous years are shown in brackets.

areas of technology and administration. Job vacancies in the administrative and technical fields are advertised on Swiss jobs platforms. Regular contact is maintained with the Regional Job Centers (RAV) and services such as advice on integration from the disability insurance offices and other employment integration support are made use of. Employees from the Human Resources departments are made aware of the legal requirements and recommendations for giving priority to Swiss nationals in recruitment, and national status is clarified in applications.

Integration of people with disabilities into the workplace

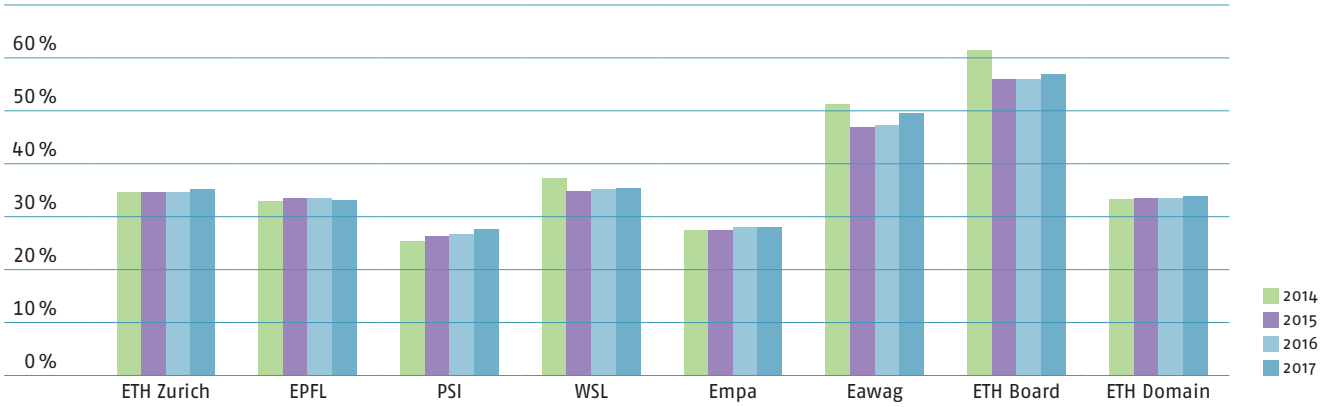
The institutions of the ETH Domain, as socially responsible employers, have played an active role for years in the integration and reintegration of people with physical or mental disabilities. This involves, for example, working with the disability insurance offices and other specialist organisations to provide internships to help prepare people for reintegration into the workplace. Case management activities, which provide support for people with health problems, have been expanded in all the institutions of the ETH Domain. For years, the institutions of the ETH Domain sought to offer employees who are unwell or partially incapacitated a position that is appropriate to their new situation wherever possible.

Fig. 26: 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. 27: Development in the proportions of women by institution



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

Fig. 28: Source of funds by function group

Function group		Professors (all)	Scientific personnel	Technical personnel	Administrative personnel	Total
Source of funds						
Total federal contribution Federal financial contribution	2016	743.4	5,967.3	2,806.4	2,317.8	**11,834.9**
	2017	756.7	5,955.0	2,858.1	2,393.4	**11,963.2**
	Δ 2016 / 2017	13.3	−12.3	51.7	57.6	**128.3**
Third-party resources Research funding (SNSF, CTI / Innosuisse, NCCR, SUC), government-funded research and EU research programmes	2016	35.4	3,774.5	212.0	82.8	**4,104.7**
	2017	35.4	3,902.7	225.6	106.1	**4,269.8**
	Δ 2016 / 2017	0.0	128.2	13.6	23.3	**165.1**
Industry-oriented research, donations / bequests	2016	26.6	1,310.5	338.4	177.1	**1,852.6**
	2017	31.4	1,348.1	355.4	190.1	**1,925.0**
	Δ 2016 / 2017	4.8	37.6	17.0	13.0	**72.4**
Total	2016	805.4	11,052.3	3,356.8	2,577.7	**17,792.2**
	2017	823.5	11,205.8	3,439.1	2,689.6	**18,158.0**
	Δ 2016 / 2017	18.1	153.5	82.3	111.9	**365.7**

Source of funds according to function groups (in FTEs) in 2017 and compared to 2016. Δ (delta) shows the absolute change compared to the previous year. Figures exclude apprentices (473.6 FTEs) and trainees.

Outlook – 2018 objectives
Previous experience has shown that personnel policy objectives and strategies that have an impact on social norms and traditions can only be implemented over an extended period of time. This will also be true in the future. The ETH Board and the institutions of the ETH Domain will continue to base their personnel policy on respect, appreciation, dialogue and trust in 2018. They continually adapt the ETH Domain's regulations on human resources to reflect social and political developments and changing socio-political requirements. The employees and social partners were given an opportunity in 2018 to comment upon the requirement profiles which have been updated and refined by HR specialist personnel and by workforce representatives from the entire ETH Domain – a course of action commissioned by the ETH Board on the basis of recommendations from the evaluation of the pay system.

The ETH Board has decided to cushion the financial impact of the adjustment of the technical parameters and lowering of the commutation rate with the PUBLICA pension scheme effective from 1 January 2019 in such a way that future pension benefits will be reduced by a maximum of 4%.

Appointment of professors

In 2017, the ETH Board dealt with 140 professorial matters. The ETH Board appointed a total of 61 professors: 13 female and 28 male professors at ETH Zurich and 5 and 15 respectively at EPFL.

APPOINTMENTS

61

Professors, of which 13 women and 28 men at ETH Zurich, and 5 women and 15 men at EPFL

RETIREMENTS

18

Retirements on grounds of age

The total of 61 appointments break down as follows:

FULL PROFESSORS
18
of which 3 women and 15 men

ASSOCIATE PROFESSORS
21
of which 8 women and 13 men

ASSISTANT PROFESSORS WITH TENURE TRACK
14
of which 4 women and 10 men

ASSISTANT PROFESSORS WITHOUT TENURE TRACK
8
of which 3 women and 5 men

The 23 appointments (15 at ETH Zurich and 8 at EPFL) were either promotions from associate to full professors or from assistant to associate professors.

Women accounted for 29.5% of all appointments, up on the previous year (24.1%).

In addition, the ETH Board awarded the title of professor (titular professor) to 1 female scientist and 12 male scientists.

Retirements and resignations
In 2017, the ETH Board was informed of 18 resignations for reasons of age (retirements), 11 from ETH Zurich and 7 from EPFL. Furthermore, ETH Zurich and EPFL advised the ETH Board of a total of 5 resignations for other reasons.

New Gender Strategy 2017–2020

In 2017 the ETH Board introduced its Gender Strategy for the period from 2017 to 2020 with the objective of continuing to increase the proportion of women in the ETH Domain in the coming years.

In 2017, women accounted for 30.6% of students, 30.0% of academic staff and 14.9% of professors. This equates to a slight increase at all levels of the academic career spectrum (2016: 29.7%, 29.5% and 13.9% respectively). The figures are encouraging and reveal a positive trend. To keep moving in this direction, the ETH Domain launched a strategy in 2017 for gender balance and equal opportunities between women and men. The Gender Strategy 2017–2020 allows a clear and coherent policy to be guaranteed throughout the entire ETH Domain. It affects all women and men in the ETH Domain – students, technical or administrative staff, academic staff and people in leadership positions.

The strategy is geared towards five key points: embedding equal opportunity firmly; raising awareness of gender stereotyping and gender-related prejudices; treating people with respect and appreciative communication; career development for women at all levels; and favourable conditions for a good life-domain balance.

Each of the institutions of the ETH Domain is separately responsible for the implementation of the Gender Strategy 2017–2020 and has had a professional structure for the development and implementation of equal opportunity in place since 2017. In 2017, the institutions of the ETH Domain once again spent over 0.4% of the federal financing from the government promoting equal opportunities. For example, more women are being recruited as professors, action plans drawn up, monitoring is being implemented and programmes and projects are being carried out to raise awareness of gender-related prejudices and encourage more girls to join the next generation of young scientists. The institutions are also striving to create measures which enable an academic career to dovetail with other aspects of people's lives.

In addition, the institutions are further enhancing the ways in which they can help women in developing their careers. The "Fix the Leaky Pipeline!" (FLP) programme offers courses and coaching to doctoral students and postdocs which will be useful to them in their careers. This flagship programme of the ETH Domain celebrated its ten-year anniversary in 2017, which the organising committee used as an opportunity to gather the views of former participants in the anniversary brochure.

www.fix-the-leaky-pipeline.ch
www.ethboard.ch/genderstrategy

"Women should not hesitate to follow this kind of programme to benefit fully from timely and strategic career planning already in the early stages of their work life".
Dr Diana Coman Schmid (left), Personalized Health Data Services Manager, ETH Zurich, two children. *(Photo: Alain Herzog/FLP)*

"As clinician at the CHUV but also as a researcher at EPFL, I must divide my time between these two jobs and, in addition, my two children. Thanks to the FLP programme, I learned some tools for being more effective".
Prof. Dr Olaia Naveiras (right), Clinical Researcher, Lausanne University Hospital (CHUV)/EPFL, two children. *(Photo: Alain Herzog/FLP)*

Spatial and financial master plans as the basis for real estate strategies

The first ever spatial and financial master plans of the institutions of the ETH Domain provide a new basis for deciding upon the strategic further development of the real estate portfolio. The findings obtained from this are linked to the institutions' development plans.

The ETH Board needs planning, prioritisation and decision-making principles in order to ensure that the ETH Board's real estate portfolio is managed at a high level and in order to guarantee transparency for the owner. The control tool "spatial and financial master plans" (SFMP) has been developed for this purpose.

The operation and upkeep of the ETH Domain's building stock ties up funds which are subsequently not available for the core business of the institutions. The tool can be used to show the long-term associated investments, subsequent costs and financing of all real estate that is in use or being managed or planned – irrespective of ownership – and to verify its financial viability.

The reports and real estate strategies of the institutions are based on the key figures to be determined every year on the actual status, as well as on the medium and long-term (4 and 12-year) planning and forecast for the portfolios. During 2017, the 4-year SFMP reports, prepared for the first time in 2016, were partially revised or updated and work started on a consolidated overall report.

Strategies to develop the portfolio further

In 2017, ETH Zurich consolidated its location strategy with the two major campuses in Zurich (Zentrum and Hönggerberg), two external campuses in Basel and Ticino, as well as smaller external sites. Together with Zurich council and the cantonal authorities, the Zurich University and University Hospital, it has set the course for the total renovation of the Zurich Zentrum University District, in particular the infrastructure for medical provision. In future, ETH Zurich will plan and create its new buildings increasingly in line with important research technologies and themes, as well as on the basis of scientific concepts.

EPFL wishes to preserve its architectural heritage and to develop the real estate portfolio in line with usage needs within the financial budget. There has been particularly strong growth in demand for laboratory space for chemical and physical applications. For this purpose, the current buildings will be altered and the possibility of constructing of a new Advanced Sciences Building will be considered in the medium term.

The revision and completion of the SFMP enabled the PSI to define more comprehensive long-term plans for the first time in 2017. This takes into account moderate growth, the preservation of the value and functionality of installations, dismantling nuclear facilities and the elimination of pollutants.

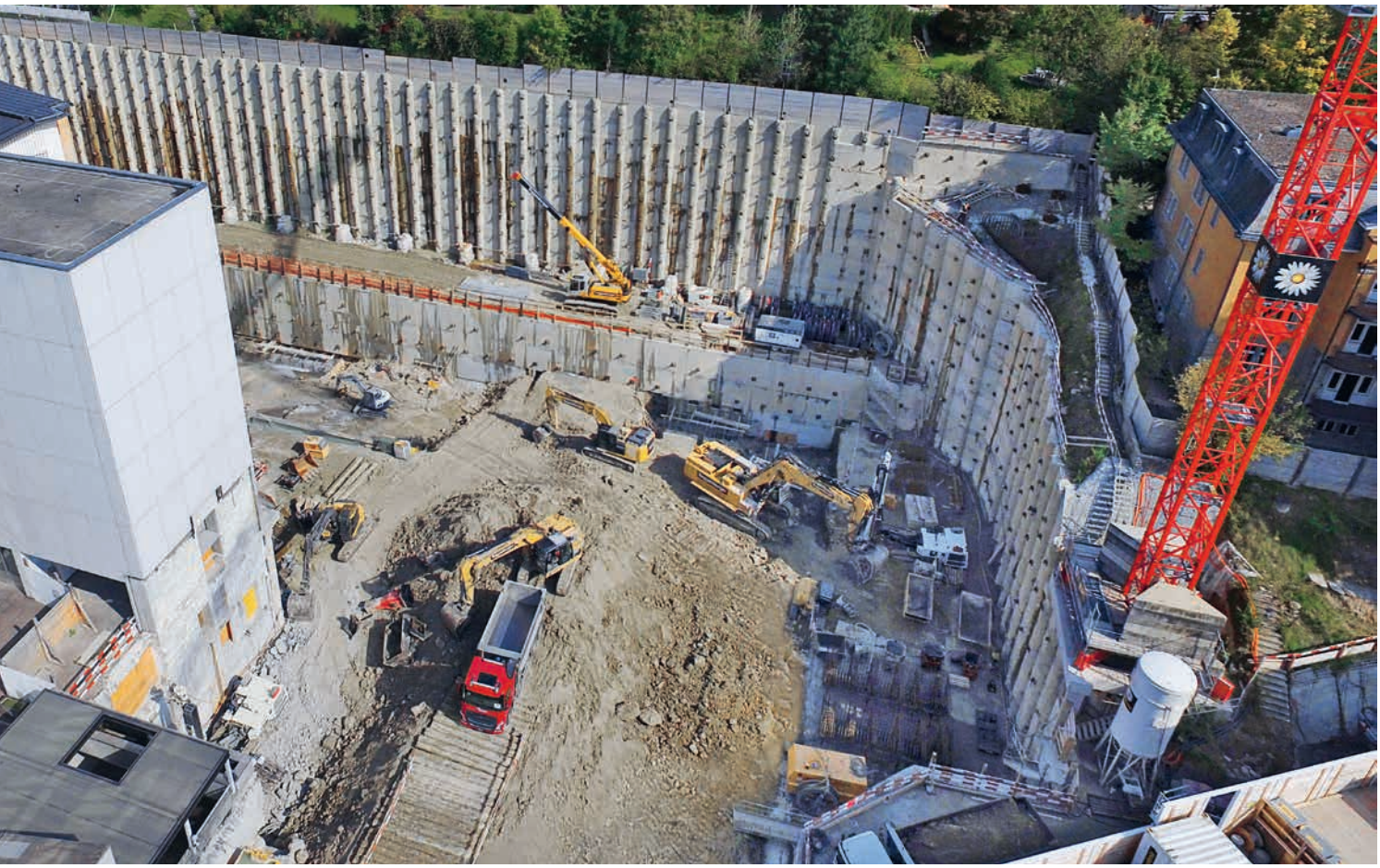
The SFMP for WSL provides an indication of the status of the real estate portfolio at both sites in Birmensdorf and Davos, illustrates the current use of the site and shows existing reserves. The joint SFMP at Empa and Eawag, which was updated in 2017, is also the basis for their real estate strategies.

Ongoing and completed projects of 2017

As part of the investments in new-builds, extensions and repairs for the targeted improvements for users, the institutions of the ETH Domain are also improving energy efficiency, interior air-conditioning, disability access, fire protection, earthquake safety and running costs.

Larger new-build projects by ETH Zurich in 2017 included the creation of the new GLC research building with laboratory and office space at Gloriastrasse for D-HEST. In Basel, there was the preparatory work on the new BSS building on the Schällemätteli Campus – a modern research building in the immediate vicinity of the Life Sciences institutions of the university and the university hospitals in Basel.

The Agrovet building project for agricultural research in Lindau-Eschikon, carried out together with the University of Zurich and Strickhof Agricultural College, was officially opened. The refurbishment and extension of the listed machine laboratory (ML/FHK) has been continued. ETH Zurich created a modern, versatile laboratory building on the Hönggerberg Campus with the renovation of the power supply and two-storey enlargement of the HPM frontage.



Excavation work for the new GLC research building at Gloriastrasse for the Department of Health Sciences and Technology (D-HEST). *(Photo: David Kuenzi)*

EPFL carried out two projects to respond to the developments on the growing campus and to guarantee that future energy demands can be met: building a second transformer station and upgrading the existing one as well as converting and renovationg the energy centre on top of which a data centre will be built. There is also a new childcare facility under construction.

The PSI started operating the SwissFEL large-scale research installation. The project for the dismantling of the Proteus research reactor went into the realisation phase. Preparations were made for the ORAB new-build project (store for low-level radioactive waste).

At the Davos site, WSL assessed the possibility of building a replacement for D wing, as there is an acute lack of space there.

Empa implemented important repair and refurbishment work; the Empa/Eawag master plan was finalised. Work has got under way on the civil engineering work for the services supply project at the shared campus in Dübendorf. Further modules were handed over for operation at the NEST construction test building.

Eawag completed the general contractor tendering process for the construction of a replacement laboratory pavilion and prepared the documentation for the planning application in January 2018.

Investments and source of funds in 2017

The investment credit in 2017 for the entire ETH Domain was 152.9m CHF following a credit reallocation to the government financial contribution of CHF 24.6m (13.9%), i.e. below the previous year's value (CHF 165.1m). The main reason for the credit reallocation was reduced spending due to building delays, as well as the loss of project planning due to austerity measures by the Federal Government. 21.8% of the investments were accounted for by new buildings, and 78.2% by preserving value and functionality. Furthermore, small amounts of third-party funding were used for building measures, and CHF 62.1m was used from the Federal financial contribution for investments in user-specific operating facilities owned by the institutions. The volume of construction authorised by the ETH Domain in 2017 amounted to CHF 216.1m (see fig. 30). The ETH Domain received an accommodation loan of CHF 278.4m in 2017 for the calculated rent on the state-owned real estate. The Source of Funds chart (see fig. 30) shows the sources of funds for the buildings in the ETH Domain since 2009. The annual fluctuations are dependent on the type of grant and the scope of the current construction projects. However, third-party funding cannot be factored into plans as it is very project-specific.

A private investor implemented a student accommodation project worth around CHF 35m on EPFL's Triaudes Campus. This will later be operated and maintained by third parties. The PARK INNOVAARE project at the PSI is about to enter the implementation phase. The total extent of investor funding for the first phase will be approximately 160m CHF.

Space: Real estate management in figures

The ETH Domain uses more than 390 buildings and around 70 facilities on 130 plots of land. The main usable area reported at the end of 2017, which covers 966,721 m², represents practically no increase compared with 2016, due to finished new-builds and recently started refurbishments. The acquisition value of the ETH Domain's real estate portfolio at the end of 2017 amounted to CHF 7.75bn. In terms of value, this represents about one third of the entire real estate portfolio of the Federal Government. The carrying amount is around CHF 4.25bn. There was no adjustment of the portfolio due to real estate sales in 2017, but there was a staged payment arrangement with the PSI.

At ETH Zurich, new buildings are being constructed in Zentrum, on Hönggerberg and also in Basel. At EPFL, the space growth 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. 31). The Biotech Campus in Geneva made a significant contribution to this.

The mix of space (see fig. 32), with state-owned buildings for own use and use by others, and buildings rented by third parties (in m² of main usable area), 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.

Maintaining value and functionality: Value kept at a high level

The ETH Board is legally obliged to maintain the value and functionality of the state-owned real estate of the

Fig. 30: Source of funds for ETH Domain constructions (in CHF millions)

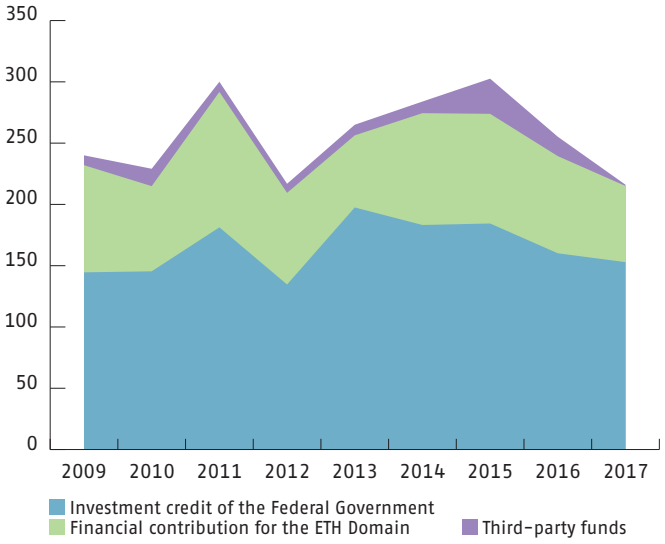
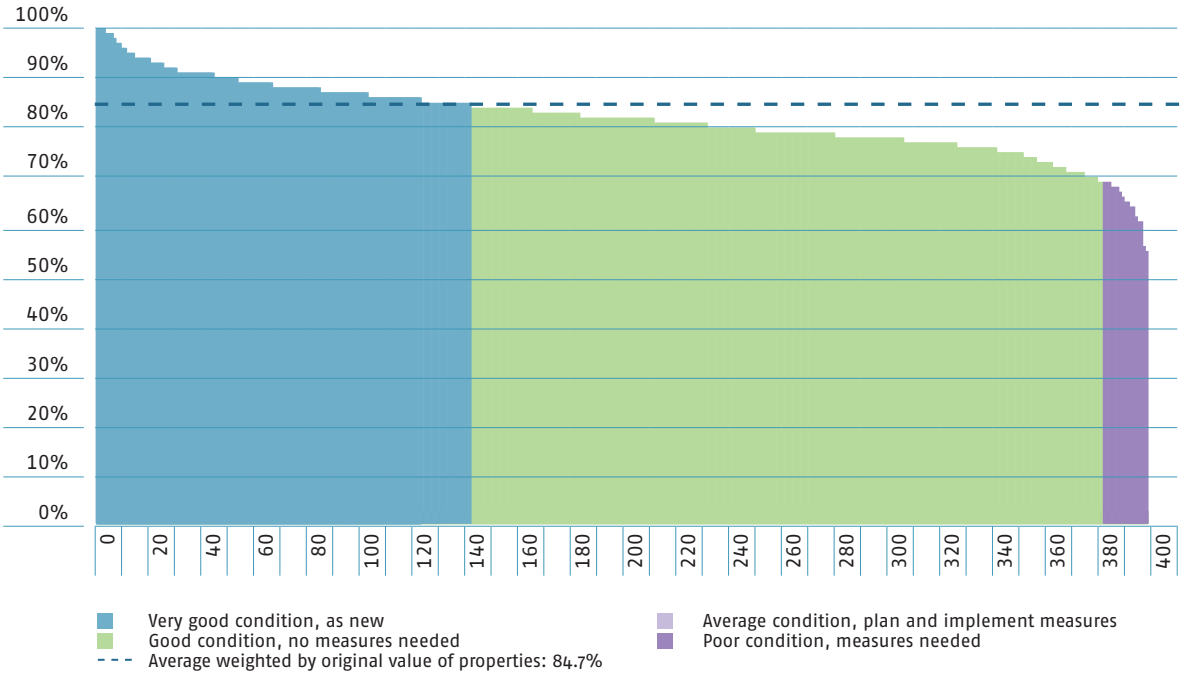


Fig. 29: Condition value as of 31 December 2017



ETH Domainand this is part of Objective 9, real estate management(see p. 76 f.). The average age of all properties is around 50 years. 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. An example of a large refurbishment subject to conditions, i. e. the preservation of protected buildings, is the project involving the Machinery Laboratory and District Heating Plant of ETH Zurich costing more than CHF 120m. Renovation projects in excess of CHF 630m are currently included in the 2018–2021 real estate investment plan. They triggered an investment volume of some 90m CHF in 2017. In addition, ongoing maintenance work amounting to some CHF 50m was funded from the state financial contribution.

The two Federal Institutes of Technology and the four research institutes use the same standard STRATUS methods to assess the condition of buildings and to plan maintenance work. The current value of the properties that have significant volumes and value is shown for each year (see fig. 29). The trend over several years shows that despite the old age of some of the buildings, their current value remains consistently high in relation to the reinstatement value. One reason for this lies in the dynamic nature of the institutions of the ETH Domain. Many renovation projects are triggered by a need to adapt the use of a building. These measures and approaches demonstrate how the ETH Domain complies with its responsibility to manage the buildings placed at its disposal by the Federal Government in a sustainable manner, appropriately preserving their value and functionality.

Fig. 31: Development of the main usable area by institution in %

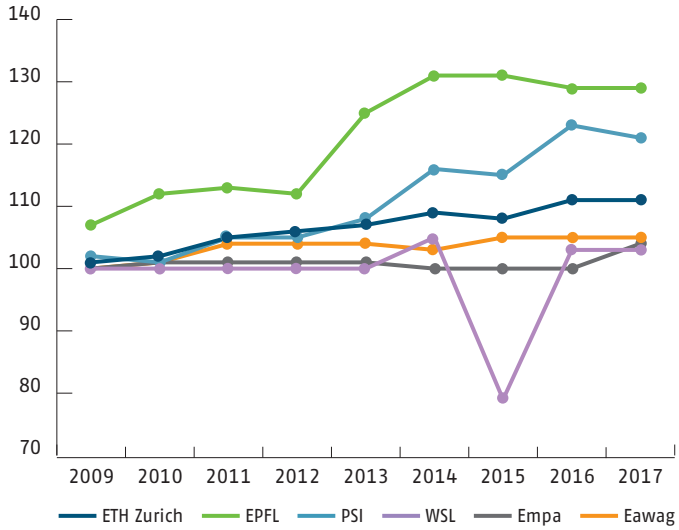
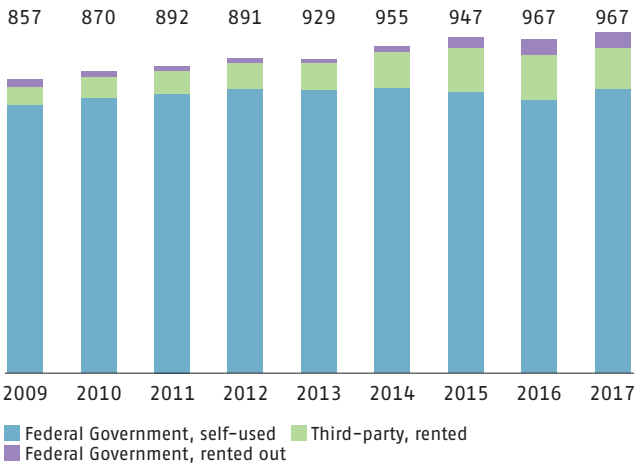


Fig. 32: Mix of areas (in 1,000 m²)



2018 construction programme: ETH Zurich major projects

The ETH Domain aaplies 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 2018 estimate on 14 December 2017.

Proposed by the ETH Board in 2017 and adopted by the Federal Council in December 2017, the 2018 construction programme, which amounts to a total of CHF 155.4m includes a major project for CHF 11m: the HI cluster (power substation) on the Hönggerberg Campus. The core element of the energy concept is the anergy network. This involves storing waste heat emitted from machines and buildings in the summer via a probe field in the ground. This heat can then be used to keep the building heated in the winter.

A credit line of CHF 144.4m has been requested for 2018. Credit lines make it possible to carry out construction projects costing up to CHF 10m, and to plan projects over CHF 10m.

A request has also been made as part of the 2018 building programme for an additional loan of CHF 6.5m for contingent credit V0233.01 "ETH buildings 2014, Gloriastrasse" of CHF 120.5m for the construction of the new laboratory and office building in Zurich city centre. Due to the application procedure in operation at that time, the GLC project currently has an insufficient reserve ahead of the commencement of the construction work. The total borrowing and the additional loan together amount to CHF 161.9m.

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 separated from the annual instalments from the Federal Government to the ETH Domain according to its 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 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 and 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.

Fig. 33: Quantity structure of the ETH Domain portfolio

CHF millions	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Buildings / facilities							
Quantity	178	80	137	24	28	13	460
Original value	3,550	1,643	620	101	359	102	6,375
Carrying amount	1,430	930	252	48	113	55	2,828
Plots							
Quantity	70	21	15	16	4	4	130
Carrying amount	691	247	30	24	63	10	1,065
Carrying amount of installations under construction	245	45	14	2	4	2	312
Building rights (not valued, in compliance with regulations)							0
Total assets (carrying amount real estate)	**2,366**	**1,222**	**296**	**74**	**180**	**67**	**4,205**
Provisions (e.g. for polluted sites, asbestos, radioactive waste)							258

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

Fig. 34: Investments

CHF 1,000	ETH Zurich	EPFL	PSI	WSL	Empa	Eawag	Total
Investment credit from Federal Government	96,080	39,000	11,810	1,170	3,140	1,700	152,900
of which for new or replacement constructions	35,564	21,180	5,084	0	0	1,196	63,024
of which for maintenance of value and functionality	60,516	17,820	6,726	1,170	3,140	504	89,876
Financial contribution investments (for user-specific construction)	50,137	2,213	6,801	546	1,965	479	62,141
Third-party resources	902	–5,000	0	0	5,128	0	1,030
Construction expenses of the Institutions	147,120	36,213	18,611	1,716	10,233	2,179	216,072
Main usable area (m²)	475,280	281,860	110,750	20,080	61,310	17,440	966,720
Construction expenses per m² main usable area (CHF / m²)	310	128	168	85	167	125	224

2017 investments in the state-owned real estate, 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.

Mobility: identify, control and avoid

Mobility accounted for 36% of final energy consumed in Switzerland in 2016. Consequently, the institutions of the ETH Domain accordingly attach great importance to this issue and have taken numerous steps in recent years to reduce energy consumption and to lessen the associated environmental impact.

Although the greatest demand for energy within the ETH Domain can be attributed to the research activities which are carried out in just under a dozen large-scale research facilities, the institutions have long had an eye on the environmental impact and energy consumption associated with mobility. They are focusing here on the three strategic lines of attack, namely identify, control and avoid. The institutions have set up their own mobility management systems based on their locations and different needs and have implemented numerous measures for more sustainable mobility in recent years.

Up to 50,000 people travel around the various campus facilities during term-time at the Zurich Zentrum and Zurich Hönggerberg campuses (ETH Zurich) and in Ecublens (EPFL). With student and employee numbers rising rapidly in recent years, the pressure on transport capacity is also increasing. Therefore, it makes obvious sense to promote student housing near and on the campus, public transport (by providing discounted seasonal passes) and non-motorised traffic (pedestrian and bicycle). For example, Eawag made a specific contribution to the latter during the building work on Stettbach station, installing a separate bicycle storage facility which is locked and reserved for employees of Empa and Eawag.

ETH Zurich launched a mobility platform in April 2016 to promote sustainable mobility and to lower CO_2 emissions. The focus is on campus mobility, air travel, logistics and obstacle-free mobility. In order to reduce its greenhouse gas emissions from air travel, it has decided that the departments are to develop reduction targets with an action plan for achieving this. In terms of campus mobility, there is enhanced local provision of e-bikes, for instance, and the frequency of ETH Zurich's own shuttle service from the city centre to Hönggerberg has been increased with a third bus. A similar thing has happened at the PSI, where further improvements have been made to the connection with direct lines (Brugg-PSI and Siggenthal-Würenlingen-PSI). The EPFL campus in Ecublens is mainly accessible by the local "Metro", as is the neighbouring University of Lausanne. Consequently, the metro is used to its full capacity at peak times. Nevertheless, EPFL increased parking charges by 260% in 2016 and introduced an innovative parking management system that uses a smartphone app. The revenues are to be used for the benefit of environmental projects. Parking charges were also increased sharply at the Empa and Eawag campus in Dübendorf in 2017; the daily parking charge rose from CHF 1.50 to CHF 4 (from 2017), and the annual charge is set to rise incrementally by 50% (2017) and by 100% to CHF 600 from 2018.

Mobility monitoring, a process that allows the evaluation of air travel, among other things, and which has been working well for years at EPFL, has also been undergoing development and expansion at the PSI since 2016. The issue is attracting increased attention in all institutions because the CO_2 emissions caused by air travel have now exceeded those resulting from the heating and cooling of the buildings. The focus of the action plan is concepts for avoidance and offsetting. In 2017, the PSI expanded its video-conferencing facilities and built a platform to promote carpooling.

Since 2017, WSL has applied a system of offsetting entire CO_2 emissions from the previous year (buildings, road traffic, air travel). At Empa, heads of department have been entitled to request that staff offset CO_2 emissions from air travel within their areas since 2017, either through airline offers or through myclimate, for example. On the Empa / Eawag campus in Dübendorf, the 2017 revision of the master plan envisages parking cars in managed car parks on the edge of the campus in the future in order to keep the site largely car-free.

Energy and environment within the ETH Domain
The institutions are responsible for the operations-led energy and environmental management in the ETH Domain. The implementation of measures within "The Confederation: exemplary in Energy" project is due to run until 2020 and is on course.

ETH Zurich laid important foundations in 2017: Senior Management approved the Energy Master Plan for the Zentrum Campus, which will be implemented between 2018 and 2025. This includes, for example, the replacement of the existing decentralised cooling system with a cooling network and the long-term goal of connection to a lake-water pipeline. In addition to energy efficiency, this will also increase the security of supply. A planning project has been started for the supply of energy to ETH Hönggerberg, to ascertain how the protected HP area can be connected to the energy grid effectively. The Action Plan for Photovoltaics (PV), which was adopted in 2017, seeks to integrate a PV roof system on all new buildings. The aim is to create at least 500 kWp of additional PV capacity by 2022. ETH Zurich is breaking new ground in operational improvements by systematically optimising all the operating parameters of the HIB teaching, research and robotics lab, which was only opened in 2016, during the adjustment phase.

www.umwelt.ethz.ch

2017 was a particularly eventful year for EPFL in terms of new sustainability projects. The 4th "Act for Change" event in May inspired almost 700 employees on the campus to take part in the competition to find the best practice in social and environmental responsibility. On the issue of waste, a major trial was started in the restaurants and food trucks with washable dishes as a substitute for disposable table items. The initial results are very promising. Various mobility-related projects have emerged thanks to the new mobility fund: the introduction of a 15% employee discount on season travel passes on the Mobilis network, launch of the first self-service Cargobike hire scheme in Switzerland, creation of 600 new bicycle parking spaces (two-tier), and construction of the new Bike Center for the purchase of new and used bikes, as well as minor repairs.

exploitation-energies.epfl.ch
developpement-durable.epfl.ch

Numerous steps were taken at the PSI in 2017, particularly in the area of large-scale research facilities. The biggest project currently under way concerns the upgrading of the helium compressors of the refrigeration systems. The project was supported by a subsidy from the SFOE "ProKilowatt" programme and has an annual energy saving potential of approx. 1.28 GWh. The replacement of selected vacuum pumps on the Swiss Spallation Neutron Source SINQ (also backed by ProKilowatt) enables power consumption for pump operation to be reduced to about one-third of the previous value.

www.psi.ch/about/energieleitbild and
www.psi.ch/about/umweltleitbild

WSL has decided to offset all its CO_2 emissions retroactively from 2016, caused chiefly by air travel. WSL has been pursuing a CO_2-neutral strategy in its buildings for a considerable time. WSL now saves 280,000 litres of water and 42 MWh of electricity a year (equivalent to the consumption of ten households per year) by replacing a commercial dishwasher. The WSL Environmental Group has organised a recycling day and is currently working on ways of encouraging employees to avoid flying.

www.wsl.ch/umweltmanagement

The campus concept for Empa and Eawag includes extensive plans to boost energy efficiency and to generate renewable energy. One of the measures involved the installation of a photovoltaic system integrated into the façade, consisting of innovative thin-film solar cells with a maximum output of around 30 kWp. The CIGS cells are a product of the research cooperation between the Swiss start-up Flisom and Empa. The roll-to-roll production process allows fast, cost-efficient production with low material and energy consumption.

www.empa.ch/web/resources-environment

Employees from Eawag rode their way to the top of the leaderboard in the "bike to work" campaign in 2017. Eawag was in first place in the 500–999 employees category, with a participation rate of 30% and 47 teams over a two month period. Together with Empa and the Swiss Association of Environmental Cycle Paths, Eawag also opened an adventure station, which is especially aimed at families with children. This Eawag station demonstrates in a fun way how water power is used in Switzerland and showcases measures which help our streams and rivers to provide more habitat again.

www.umwelt.eawag.ch

Fig. 35: Environment and energy data

		ETH Domain 2015	ETH Domain 2016	ETH Zurich Total	EPFL Total	PSI Total	WSL Total	Empa Total	Eawag Total	ETH Domain Trend 2017[1]
Basic data										
Energy reference area (ERA)[2]	m²	1,434,194	1,471,508	686,431	435,389	169,900	28,246	123,442	28,100	
Full-time equivalent[3]	FTE	34,827	35,310	19,847	11,164	2,023	659	972	645	
Energy[4]										
Final energy, net[7]	**kWh / a**	**436,876,537**	**430,768,848**	**171,510,283**	**98,296,921**	**133,107,126**	**4,877,241**	**18,609,536**	**4,367,741**	**427,385,195.4**
Electricity, net (not incl. self-produced)	**kWh / a**	**365,894,796**	**360,612,906**	**135,086,000**	**81,504,656**	**125,870,773**	**3,064,754**	**11,687,273**	**3,399,450**	**357,769,426**
Consumption of uncertified electricity	kWh / a	56,595,832	60,638,256	9,706,000	1,466,261	47,490,157	42,000	1,933,838	0	
Consumption of certified electricity	kWh / a	316,964,326	306,751,078	125,380,000	84,880,985	78,380,616	3,022,754	11,687,273	3,399,450	
– Electricity (without naturemade star)	kWh / a	302,657,249	292,399,481	121,380,000	78,034,040	78,380,616	2,917,552	11,687,273	0	
– Photovoltaic naturemade star	kWh / a	2,135,781	2,078,078	0	2,000,000	0	52,601	0	25,477	
– Hydro power naturemade star	kWh / a	12,171,296	12,214,009	4,000,000	4,846,945	0	52,601	0	3,314,463	
– Wind naturemade star	kWh / a	0	0	0	0	0	0	0	59,510	
Sale of electricity	kWh / a	–7,665,362	–6,776,428	0	–4,842,590	0	0	–1,933,838	0	
Heat	**kWh / a**	**68,494,879**	**67,627,075**	**35,383,000**	**16,442,265**	**6,901,353**	**1,349,078**	**6,717,605**	**833,774**	
Fuel oil	kWh / a	3,468,116	4,540,980	710,000	3,215,696	423,773	165,951	0	25,560	
Natural gas	kWh / a	57,795,344	59,752,463	39,701,000	13,168,044	0	0	6,869,872	13,547	
Natural gas BHKW	kWh / a	0	0	0	0	0	0	0	0	
District heating	kWh / a	31,108,657	28,730,003	20,482,000	333,356	6,477,580	0	642,400	794,667	
Woodchip	kWh / a	1,520,337	1,463,127	280,000	0	0	1,183,127	0	0	
Sale of heat	kWh / a	–25,397,575	–26,859,498	–25,790,000	–274,831	0	0	–794,667	0	
Fuels (own vehicles)	**kWh / a**	**2,486,862**	**2,528,867**	**1,041,283**	**350,000**	**335,000**	**463,409**	**204,658**	**134,517**	
Energy: additional information										
Energy costs, electricity and heat[5]	CHF / a	50,046,943	47,499,551	23,967,909	10,075,657	11,989,081	498,036	1,733,420	502,221	48,189,035.6
Self-generated renewable electricity	kWh / a	520,813	520,813	217,100	0	102,550	28,000	29,159	144,004	
Total sale to third parties	kWh / a	–33,062,937	–33,635,926	–25,790,000	–5,117,421	0	0	–2,728,505	0	
Water (drinking water)	**m³**	**630,749**	**649,066**	**324,846**	**178,459**	**109,325**	**8,659**	**21,500**	**6,277**	**659,928**
Materials										
Paper	**kg**	**341,961**	**411,592**	**251,500**	**105,236**	**32,228**	**7,852**	**7,868**	**6,908**	**344,133**
Paper, new fibre	kg	120,462	173,722	136,500	21,970	10,074	3,054	1,892	232	114,284
Paper, recycled	kg	221,499	237,870	115,000	83,266	22,154	4,798	5,976	6,676	229,849
Key figures: environmental impact										
Primary energy[6]	**kWh / a**	**625,358,315**	**616,876,534**	**215,354,981**	**119,883,747**	**242,857,836**	**11,070,532**	**22,416,412**	**5,293,027**	
Proportion of renewable energies	**%**	**63**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	
CO_2 emissions	**t CO_2 / a**	**36,820**	**36,776**	**15,305**	**7,298**	**10,660**	**684**	**2,512**	**317**	

[1] Provisional figures for the year under review (trend), as at: start of March 2017.
[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, primary energy as the energy is defined 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. Final energy basically corresponds to the purchased energy.

Financing statement

The Federal Government finances the ETH Domain to the tune of almost 90%. The total federal contribution provides the main chunk of this. Again the revenue from third parties increased.

Financing (revenue by source of funds)

As the owner, the Federal Government finances the ETH Domain to the tune of almost 90% (percentage in 2017: 86%). It contributes 71%, i.e. the lion's share, directly via its federal financing budget. The Federal Government contributes a further 15% on a competitive basis via the two sponsoring organisations SNSF and Innosuisse, federal government research and via funding from EU framework programmes (EU-FP) as research contributions. The desired expansion in the financing base for the ETH Domain is being achieved by research grants, to be obtained competitively from the Federal Government and from third-party funds (cooperation with the private sector). Other sources of financing are gifts, tuition fees and other revenue. This proportion rose slightly to just under 14% in 2017, and the volume also rose. The total operating expenses in the ETH Domain amounted to CHF 3.6bn in the year under review, 2017. The revenue volume of CHF 3,571m exceeds both the forecast in accordance with the budget for 2017 (CHF 3,460m), and it is also above the previous year's total in the 2016 financing statement (CHF 3,486m). Higher contributions from the Federal Government's financing contributed substantially towards the positive development. The 2017 budget report did not include the increase of CHF 40m in federal financing under Revenue.

Development in the budgetary framework for the ETH Domain from 2017–2020, credits taking into account the budgetary framework (total federal contribution)

For the purposes of implementing its strategic planning for 2017–2020, the ETH Board asked the ETH Domain to achieve average annual growth of 3.5% (ERI Dispatch 2017–2020 dated 24 February 2016/Federal Gazette (BBl) 2016 3,165). This would have corresponded to a budgetary framework for 2017–2020 of a maximum of CHF 11,005m.

Due to the financial planning of the Federal Government and the priorities defined in the ERI area, this request was not met. In ERI Dispatch 2017–2020 the Federal Council proposed a budgetary framework of the order of CHF 10,177.7m (Ø annual growth: 1.5%). The Federal chambers increased the budgetary framework by CHF 160.0m to CHF 10,337.8m. Consequently, the growth quota corresponds to an average annual growth of 1.9%. The budgetary framework utilisation amounted to 98% at the end of 2017 (CHF 10,132.4m). The effective average annual growth is 1.9%. Due to cuts (including inflation correction), the projected growth within the 2017–2020 budgetary framework will be reduced to just under 1.0%.

Fig. 36: Development of the budgetary framework for the ETH Domain 2017–2020

CHF millions	2016	2017	2018	2019	2020	2017–2020
Budgetary framework for the ETH Domain 2017–2020	**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
Net reduction to the budgetary framework for the ETH Domain		**1.7**	**–33.4**	**–60.7**	**–97.2**	**–189.6**
Total credit entitlement on the budgetary framework	**2,453.8**	**2,530.8**	**2,530.9**	**2,540.9**	**2,545.6**	**10,148.2**
Nominal growth in CHF		77.0	0.1	10.0	4.6	
Nominal growth in %		3.1	0.0	0.4	0.2	
Ø annual growth 2017–2020 (based on 2016 budget) in %						0.9
Expected utilisation of the budgetary framework in %						98.2

Fig. 37: Operating revenue by source of funds (in CHF m)

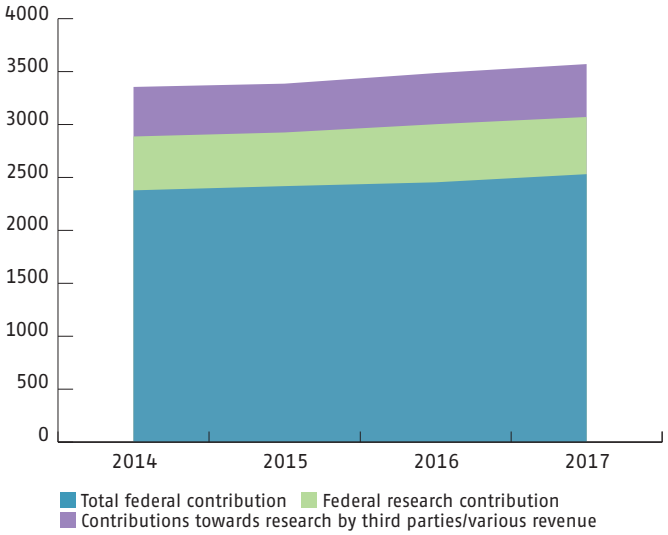
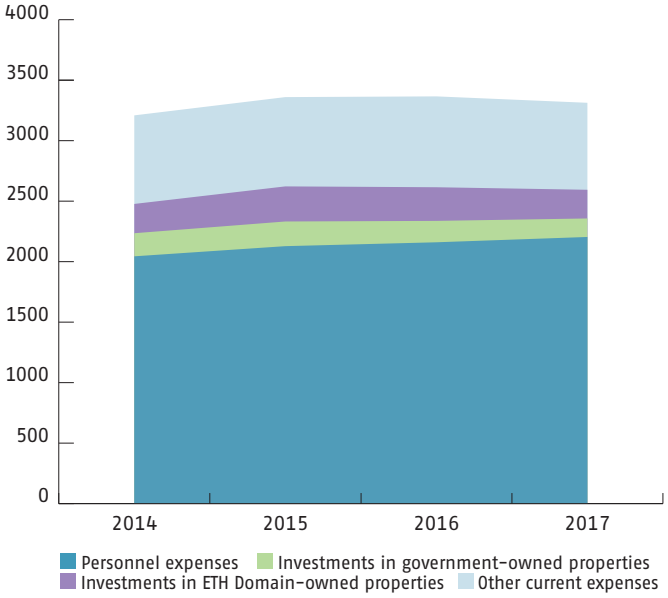


Fig. 38: Operating expenses by allocation of funds (in CHF m)



Changes in esearch contributions, other operating revenue

The research contributions by the Federal Government and those by third parties were down on the previous year and, as a proportion of the total, they are also down slightly on the previous year's level shown in the 2016 accounts. Considered in terms of absolute figures, the trend remains positive and is upward in a multi-year projection. This is also true of other operating revenue, which is also above expectations. The forecasts set out in the 2017 budget have also been exceeded overall.

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 is actually necessary, is not practicable. Consequently, identical values are shown in the transition from the financing statement to the income statement. In general, the development in research contributions can only be assessed through the balance sheet with reference to current and non-current receivables and dedicated third-party funds.

Expenses (allocation of funds)

The volume of expenses can be split into three categories, expenditure on personnel, on plant and equipment, and on investments. Human resources once again accounted for the largest proportion of the funds used (approximately 67%). Investments in property, plant and equipment, which are used by the ETH Domain, irrespective of ownership, accounted for a significantly smaller portion of the funds used by the ETH Domain, however, at a long-term average of approximately 13–15%, and almost 12% in 2017. The level of the third main component, the other current operating expenses (approx. 22%) for the infrastructure and for projects in teaching and research depends upon a number of factors (see separate Financial Report). The total operating expenses in the ETH Domain rose in the period from 2013–2017 from CHF 3.2bn to around CHF 3.4bn. The rise plateaued from the 2015 accounts, and 2017 even saw a slight fall on the previous year from almost CHF 3.4bn to CHF 3.3bn. The volume of operating expenses came out at under the amount budgeted for 2017 (CHF 3.4bn).

The following factor should be taken into consideration with regard to expenses. The budget credits for the ETH Domain approved by a parliamentary resolution are always deemed to have been utilised in full by the end of the year. In fact, however, changes can occur to the amount of reserves from the government's total federal contribution. In the year under review, reserves of almost CHF 135m were formed (2016: CHF 1m). When the credits are shown from the Federal government's perspective, they are expenses; from the perspective of the financing statement, they are part of revenue, and also contributed to the surplus revenue arising from the difference between the source of funds and the allocation of funds in 2017.

Total investment

A distinction is made in investments between usage and ownership. The total investment shows all investment, irrespective of ownership and their financing, i. e. this is the investment in the property used by the ETH Domain. Therefore, the investment in state-owned

real estate, which is financed through credit A202.0134, Investment credit for constructions of ETH Domain, is also shown.

The amount of the total investment (property owned by the ETH Domain and state-owned real estate, total federal contribution, budgetary framework view) was between CHF 400m and CHF 500m in 2013–2016. The relatively high volumes in 2015 and 2016 (fig. 39) particularly include the investment expenses on user-specific modifications (building costs plan 3) – including for investments in the SwissFEL ATHOS beamline at the PSI. There had also been a large amount of investment in information technology in the previous year, especially in the Piz Daint server at the CSCS at ETH Zurich. All these special effects ceased to apply in the year under review, and the volume of investments was down once again at almost CHF 400m (2017: CHF 390m), the average level of previous years.

Source of funds (revenue)

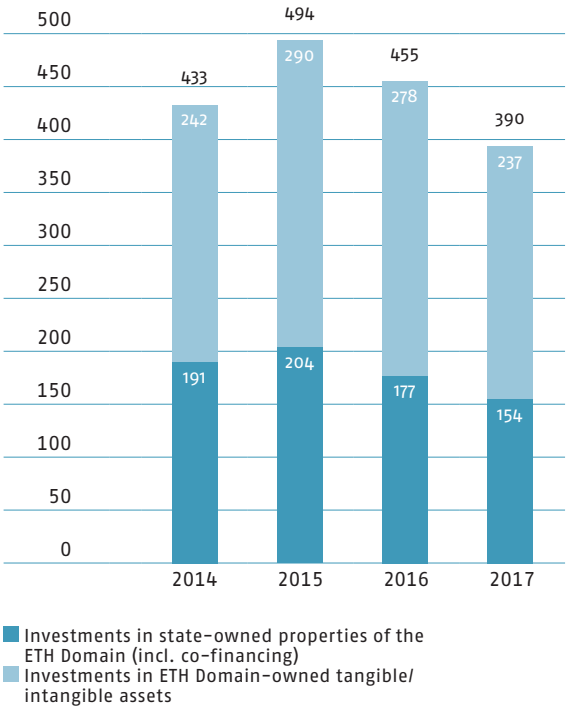
In 2017, the operating revenue amounted to CHF 3,571m. The total federal contribution accounted for 71% of this. Nominally, the total of the two credits taking into account the budgetary framework (2017 budget: CHF 2,530.8m) amounted to a rise of CHF 77m (+3.1%) on the 2016 budget (CHF 2,453.8m).

In addition to the direct total federal contribution, the Federal Government also finances the ETH Domain indirectly via research contributions. In the year under review, the Federal Government thereby contributed CHF 540m to the financial budget of the ETH Domain via its two funding bodies SNSF and Innosuisse, federal government research and via funding from EU-FP. The proportion of these contributions made by the Federal Government towards research was around 15% (2016: 16%). The proportion of contributions towards research from third-party funding and other sources of income held steady at around 14% (2017: CHF 500m). Research contributions are acquired under predominantly competitive conditions with a higher number of applicants in the 2017–2020 ERI support period and with a pool of ERI funding which has not risen to the same extent. Despite falling ERI funds, the ETH Domain recorded an increase in revenue compared to 2016. In practical terms, the Federal Government, as the owner, once again provided the ETH Domain directly or indirectly with 86% of its financing alone (2016: 86%).

Allocation of funds (expenses)

The total operating expenses in 2017 amounted to CHF 3,313m. The total was lower than the previous year's figure (2016: CHF 3,366m), and went also below the budget (CHF 3,362m). Compared to the budget, the other expenses were a key aspect of the deviation. The personnel expenses and the investments in 2017 were practically identical to the values indicated in the budget. As investment in movable and immovable assets was down compared to 2016 (2017: CHF 390m, 2016: CHF 455m), there was a proportionate reallocation to a higher proportion of spending going on human resources.

Fig. 39: Development of total investments (in CHF m)



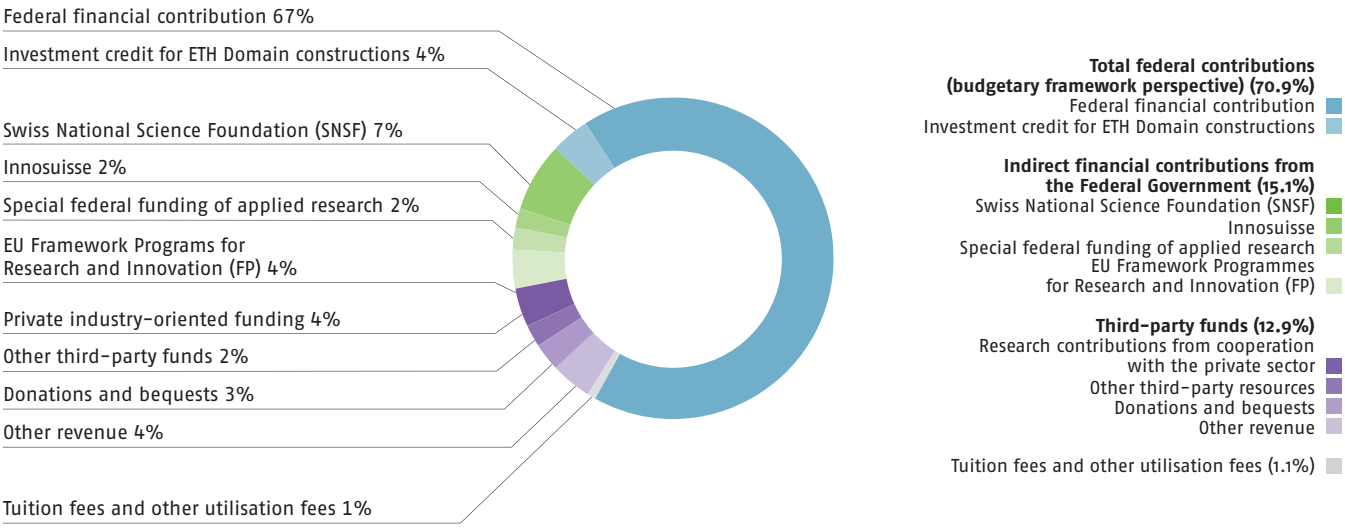
CHF 2,204m was spent on human resources (2016: CHF 2,160m). This corresponds to 66.5% of expenses (2016: 64.2%) and a rise of 2% on 2016. 18,158 full-time equivalents (FTEs) were financed. Human resources were largely funded from the total federal contribution (11,963.2 FTEs or around CHF 1,653m) and from the Federal Government's research contributions (4,629.8 FTEs or CHF 380m). Around CHF 171m of the spending on personnel was financed in association with the private sector (1,925 FTEs). The employer's contributions as a percentage of salaries in 2017 stood at 20.0% (2016: 19.8%). The calculations in the 2017 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 (2017 statement: CHF 719m) were down CHF 32m on the previous year (–4.3%).

The total expenditure shown in the financial statement, in relation to investment expenditure, is not connected to the ownership of the property but is based on usage by the ETH Domain.

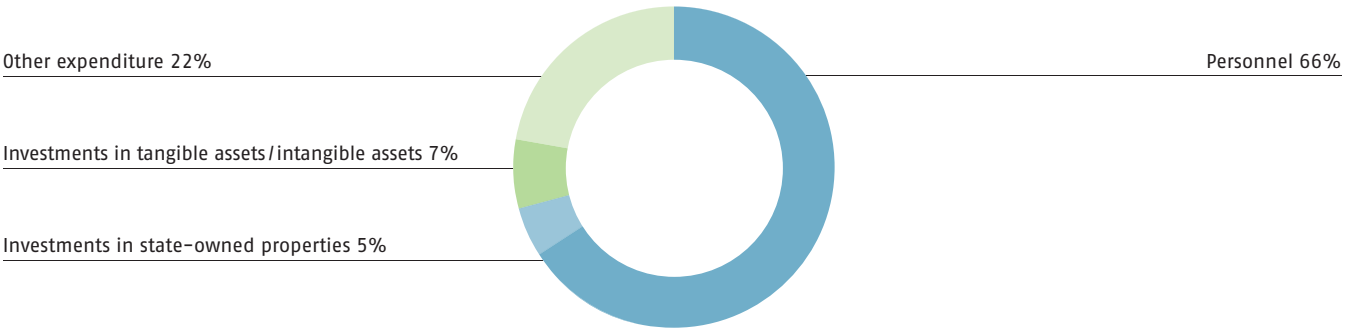
Source of funds

Fig. 40*: Consolidated 2017 statements for the ETH Domain: structure of revenues (in %)
Operating income, 2017 financial statements: CHF 3,571m (financing statement perspective)



Allocation of funds

Fig. 41**: Consolidated 2017 statements for the ETH Domain: structure of expenditure (in %)
Operating expenses, 2017 financial statements: CHF 3,313m (financing statement perspective)



* Fig. 40 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. 41 shows the expenditure from a financing perspective. It amounts to CHF 3,313m and comprises the following: personnel expenses; adjustment to the net pension expenditure in accordance with IPSAS 25; investments in state-owned properties; investments in tangible / intangible assets; materials expenses excl. accommodation expenditure; transfer expenses. Depreciation is also not part of the total after allocation of funds.

Transition from the financing statement view to the annual financial statement view

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 income statement 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 income statement 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.

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

Another aspect of the transition concerns the effect of the discontinuation of transitional provisions and, consequently, the sub-consolidations that were applied in the ETH Domain, and in particular at ETH Zurich and at EPFL, for the first time in the 2017 accounts. However, the effect on the difference between the financing statement and the income statement is marginal in the transition and in relation to this point.

Fig. 42: ETH Domain – Total federal contribution – Schema reporting and presentation of transition (simplified)
(financing statement view – revenue/expenditure and statement of financial performance view – expense/income)

	Financing statement	Transition			Income statement
CHF millions	2017	Decrease (–)	Increase (+)	Consolidation (+/–)	2017
Expenses (allocation of funds) / operating expenses					
Income (source of funds) / Operating revenue	**3,572**	**–153**	**278**	**–**	**3,698**
Total federal contribution	**2,531**	**–153**	**278**	**–**	**2,656**
Federal financial contribution	2,378				2,378
Investments in constructions of the ETH Domain	153	–153			–
Federal contribution to accommodation	–		278		278
Special federal funding of applied research	540				540
Project-oriented third-party funding / various income	502				502
Expenses (allocation of funds) / Operating expenses	**2,926**	**–**	**590**	**–**	**3,515**
Personnel expenses	2,204		99		2,303
Other operating expenses / accommodation ETH Domain	–		278		278
Depreciation	–		212		212
Other ongoing operating and transfer expenses	721				721
Investments	**381**	**–153**	**–**	**–**	**228**
State-owned properties ETH Domain	153	–153			–
Co-financing state-owned properties ETH Domain	1				1
Immovable property, plant and equipment (ETH Domain-owned)	40				40
Movable non-current assets (ETH Domain-owned)	183				183
Intangible non-current assets (ETH Domain-owned)	4				4

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- all 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.

Cover page

Top image
Digital Day 2017 on the EPFL campus: A participant proudly demonstrates how she can draw with a drawing app that she programmed herself on a smartphone in the workshop.
(Photo: Murielle Gerber / EPFL)

Bottom image
At the World Economic Forum 2017, ETH Zurich made it possible to experience the latest research results, such as the magic cube "Cubli" that can balance on a corner, jump up or control its fall.
(Photo: Andreas Eggenberger / ETH Zurich)

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