

**Intermediate Evaluation 2019
of the ETH Domain**

Self-Assessment Report

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of the ETH Domain**

Self-Assessment Report

Adopted by the ETH Board at the meeting
of 12/13 December 2018

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Foreword by the President of the ETH Board

The role of the ETH Domain for Switzerland, its positioning in the Swiss higher education landscape and the implementation of its basic mandate are at the core of the 2019 intermediate evaluation. The evaluation is based on a Self-Assessment Report by the ETH Board which covers the ETH Domain as a whole. The Self-Assessment Report addresses the Terms of Reference of the 2019 intermediate evaluation, the state of the implementation of the experts' recommendations made in the 2015 intermediate evaluation, a bibliometric analysis and further studies.

The education of specialists, research at a top international level, and knowledge and technology transfer are among the ETH Domain's core competencies and constitute central tasks assigned to it by the Confederation. Over 32,000 students and doctoral students were enrolled at the two Federal Institutes of Technology in 2018. That is 10,000 more than ten years ago. Our economy and the authorities are reliant on recruiting these much-needed specialists. The institutions of the ETH Domain are important actors in the transfer of knowledge and technology. This results in innovations in Switzerland, improves the country's competitiveness and ultimately preserves jobs and prosperity. In the ETH Domain, for instance, a total of over 650 spin-offs were set up, which created approximately 23,000 jobs. On average, one spin-off is founded every week, and a patent application is filed every second day.

Above and beyond this, the institutions of the ETH Domain play an important role in the digitalisation of Swiss business and society. Indeed, digitalisation constitutes the focal point of the four research areas which the ETH Board has specified as strategic priorities for the ETH Domain, namely Personalised Health and Related Technologies, Data Science, Advanced Manufacturing and Energy. With increasing digitalisation of all areas of our society, the importance of Cybersecurity is placing heavy demands on the ETH Domain's core competencies. In this area, the institutions of the ETH Domain already operate as centres of expertise and as partners to both public and private actors.

The ETH Board concludes that the ETH Domain plays a key role in numerous areas of Switzerland's education and innovation system – in training specialist staff, in basic research and in cooperation with industry and public authorities. A number of developments have called this role into question, however, and are a cause of considerable concern to the ETH Board.

For one thing, Switzerland's openness and internationality is regularly questioned – and yet international cooperation and networking have great significance for education, research and innovation, while Swiss science depends on highly skilled experts from home and abroad. For another, countries such as China, the USA and France are investing massively in research and development, whereas federally funded investments have stagnated, especially at the top level. This impacts on Switzerland, not only as a centre of research but also as a location for business and industry which is highly dependent on innovation. However, the ETH Domain will continue do its utmost to deploy its skills in order to generate the greatest possible benefit for our country while at the same time assuming its share of global responsibility for tackling urgent societal challenges.

On behalf of the ETH Board, I would like to thank the expert committee for its in-depth examination of the ETH Domain. We look forward to a fruitful exchange, stimulating discussions and the committee's most valued recommendations.



Dr Fritz Schiesser, President of the ETH Board



Evaluation Mandate and Structure of the Self-Assessment Report

Evaluation Mandate

The Federal Council governs the ETH Domain through strategic objectives established at four-year intervals plus a corresponding four-year financial framework with yearly global budgets. The owner of the ETH Domain is the Swiss Confederation. The ETH Domain is affiliated to the Federal Department of Economic Affairs, Education and Research (EAER). The intermediate evaluation of the ETH Domain is linked to the performance mandate which the Federal Council assigned to it for the period 2017–2020.

Federal Councillor J. Schneider-Ammann mandated a committee of national and international experts to evaluate the ETH Domain in March 2019. The evaluation mandate states: "Since 2012 the achievement of objectives in the ETH Domain is assessed annually by the Federal Council based on a report produced by the ETH Board and Parliament is duly informed. The primary focus of the intermediate evaluation, as with that in 2015, is therefore not on the achievement of objectives by the institutions of the ETH Domain, but on specific systemic questions."

The evaluation mandate contains nine Terms of Reference in three main groups (A–C) to be addressed by the expert committee. The Self-Assessment Report is structured accordingly.

Structure of the Self-Assessment Report

The ETH Board has prepared the Self-Assessment Report in close collaboration with the ETH Domain institutions. The report presents the ETH Board's view on each of the Terms of Reference.

- The main part of the present report (Chapters A–C) addresses each of the Terms of Reference separately and is subdivided into sections A.1–C.2. Each section is preceded by an assessment statement by the ETH Board that presents the assets as well as the challenges arising from the particular question(s) raised. Following this assessment statement, evidence supporting the ETH Board's view is presented.
- Chapter D summarises the bibliometric analysis which, in accordance with the mandate, is an integral part of the Self-Assessment Report. Carried out by the Center for Science Technology Studies (CWTS) at Leiden University, this analysis measures the scientific output and the impact of the publications of each of the ETH Domain institutions. The analysis is an important scientific indicator of current performance and makes it possible to track performance over time.
- Chapter E summarises two additional analyses which focus on the ETH Domain's economic contribution (Chapter E.1) and on its patent portfolio (Chapter E.2). These analyses have been included in the Self-Assessment Report as they provide relevant information regarding Term of Reference A.1 (on the ETH Domain's national role) and Term of Reference A.2 (on the ETH Domain's contribution to economic development).
- Chapter F reports on the implementation of the experts' recommendations issued in the 2015 intermediate evaluation of the ETH Domain and the respective position of the ETH Board.

The ETH Board's Strategic Planning 2021–2024 for the ETH Domain now being finalised is an important additional information resource for the experts' evaluation as it looks ahead to the next period. The document will be available before the experts' visit in March 2019.

Further information on the fulfilment of the Federal Council's Strategic Objectives for the ETH Domain for the period 2017–2020 can be found in the Annual Reports of the ETH Board on the ETH Domain. The 2018 Annual Report will be submitted to the expert committee after its adoption by the ETH Board in March 2019.

A

Basic Mandate of the ETH Domain and Coordination of the Entire Swiss Higher Education Sector

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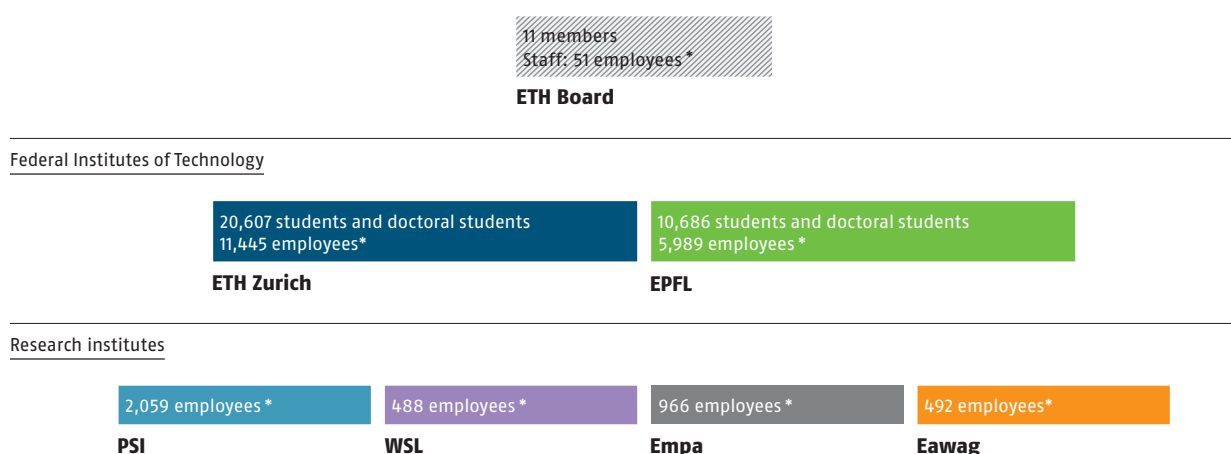
A

Basic Mandate of the ETH Domain and Coordination of the Entire Swiss Higher Education Sector

Introduction

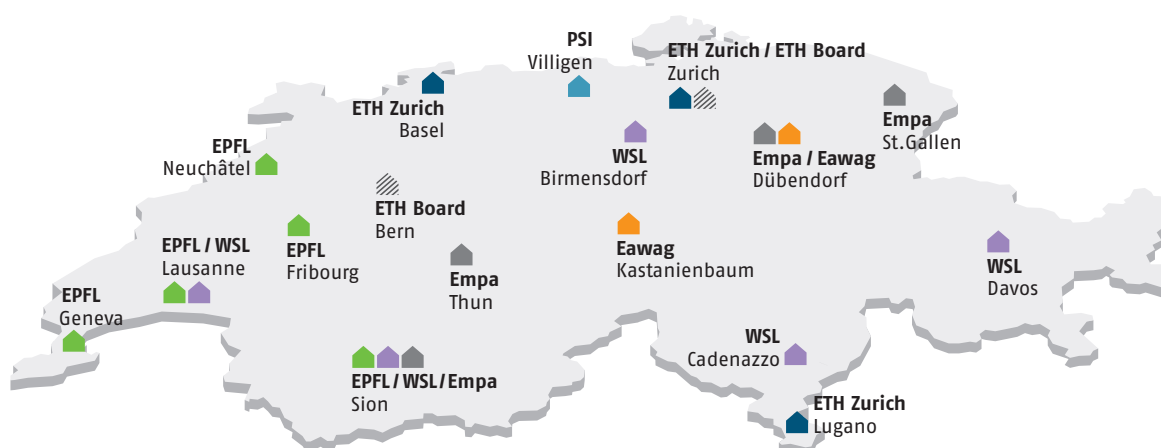
The ETH Domain comprises the two Federal Institutes of Technology, ETH Zurich and EPFL, and the four research institutes PSI, WSL, Empa and Eawag. The ETH Board is the strategic governing and supervising body of the ETH Domain (cf. Figure 1). The ETH Domain is firmly anchored in Switzerland (cf. Figure 2, and Appendix A.5) and fulfils its basic mandate according to the principles laid out in the Mission Statement.

Figure 1: The ETH Domain



* Employment contracts (including doctoral students) as of 31 December 2017

Figure 2: The ETH Domain's presence in Switzerland



Mission Statement of the ETH Domain¹

The ETH Domain serves society through the pursuit of knowledge and the beneficial application of its science. The ETH Domain institutions share responsibility for education, research, and knowledge and technology transfer. As degree-granting institutions, the technical universities ETH Zurich and EPFL play a leading role in Switzerland's educational system, and are supported in this role by the research institutes PSI, WSL, Empa and Eawag. With their thematically based activities, the research institutes offer continuity in knowledge and technology transfer.

In fulfilling this mission, the six institutions of the ETH Domain are committed to the following principles:

- **Innovative, research-based education of the highest quality.** The ETH Domain institutions educate students to be independent thinkers who will be well equipped to shape the future as responsible members of society. Graduates of ETH Zurich and EPFL have the ability to develop both subject-specific as well as interdisciplinary and transferable skills, and to work on complex and system-oriented problems.
- **Excellence in research and freedom of inquiry.** Research that pushes the frontier of human understanding is pursued with the highest degree of rigor and integrity. To promote pioneering research, the ETH Domain develops and maintains large-scale research infrastructures that are supported by expert personnel and are available to both internal and external users. The ETH Domain engages the best-qualified staff it can attract, and offers outstanding resources to ensure that scientific knowledge is conserved and transferred to its students. The ETH Domain supports a broad range of investigator-led activities, fostering creative individuals and teams driven by their own motivation and curiosity.
- **Knowledge and technology transfer for the benefit of society.** The ETH Domain recognises its obligation to work for the benefit and well-being of society, to increase national and international prosperity, to create economic value and to preserve environmental and public goods. All the ETH Domain institutions foster the uptake of research results into technologies, practice and policy-making in order to strengthen the productivity, competitiveness and innovative capacity of the Swiss economy. In this way, the ETH Domain contributes to a sustainable economy and makes its talent available for projects of national priority.
- **Ethical conduct and social responsibility.** The ETH Domain recognises that scientific integrity underpins all progress in science. In addition, the ETH Domain accepts the responsibility for creating and maintaining work environments that promote diversity and trust. All staff members and students are treated with respect, regardless of gender, cultural and social background. The values of sustainability and equity are promoted as the basis of a just and secure future. The ETH Domain upholds the principles of social responsibility respected by Switzerland as a whole and shares the global responsibility to tackle societal challenges and ensure environmental sustainability.

¹ Strategic Planning 2021–2024 of the ETH Board for the ETH Domain

The Strategic Objectives of the Federal Council for the ETH Domain

The Federal Council sets the strategic objectives for the ETH Domain – including strategic initiatives, financial and infrastructural goals as well as personnel-related objectives – for a period of four years. For the period 2017–2020 ten strategic objectives² were defined. The core tasks of the ETH Domain institutions are teaching, research, research infrastructures, and knowledge and technology transfer, plus their role in society. The corresponding objectives are:

- The ETH Domain provides teaching which, in an international comparison, is first-class, research-based and appealing to students.
- The ETH Domain defends its international leading position in research.
- The ETH Domain operates and develops research infrastructures.
- The ETH Domain fosters cooperation and dialogue with the economy and society in order to strengthen Switzerland's capacity to innovate and compete.
- The ETH Domain plays an active role in shaping the Swiss higher education area.
- The ETH Domain will further expand cooperation and networking with the world's leading institutions and strengthen its international standing.
- The ETH Domain maintains a dialogue with society and performs tasks of national interest.

² The Federal Council's Strategic Objectives for the ETH Domain for the Period 2017–2020
<http://www.ethrat.ch/en/eth-board/governance-eth-domain/eri-message-strategic-objectives>

A.1

The ETH Domain's National Role

Excerpt from the Mandate:

"What role does the ETH Domain play in a national context, particularly in the core areas of its basic mandate: teaching, research and knowledge and technology transfer, and in further areas (national tasks, research infrastructure, public relations, etc.)?"

A.1 The ETH Domain's National Role

Assessment by the ETH Board

Assets

The ETH Domain institutions' excellence in teaching, research and innovation as well as their international orientation are their most important assets a) in global competition among higher education and research institutions and b) for creating sustainable societal, economic and environmental benefit at the national and international level. The ETH Board holds that the ETH Domain plays a leading national role in the core areas of its basic mandate.

- **Research-based education:** Related to research-based education, the unique contribution of the ETH Domain to the Swiss higher education sector lies in the focus on the STEM (science, technology, engineering and mathematics)³ fields in which ETH Zurich and EPFL, complemented by the research institutes, teach increasing numbers of students and doctoral students and significantly contribute to alleviate the skills shortage in Switzerland. In specific STEM fields with high relevance for Swiss industry, research-based education at university level in Switzerland is exclusively provided by ETH Zurich and EPFL. Moreover, the ETH Domain assumes its responsibility for offering students competencies in entrepreneurship as well as for addressing societal and environmental impacts of (new) technologies. Further, ETH Zurich and EPFL play important roles in developing and implementing innovative forms of teaching and in offering courses in new fields. The research institutes contribute to study programmes in their respective fields of expertise and provide opportunities for bachelor's, master's and doctoral students to conduct their theses at the research institutes.
- **Fundamental research:** The ETH Domain institutions perform fundamental research on a world-class level (cf. Bibliometric analysis, Chapter D). This is essential for the ETH Domain's contribution to Switzerland's innovative power, since fundamental research is the most important source of ground-breaking innovation. In specific research fields (e.g. energy, digitalisation), the ETH Domain assumes a leading and coordinating role for research in Switzerland. Fundamental research, combined with the interdisciplinary research interfaces within the ETH Domain – with their unique potential for generating breakthroughs in research and helping solve Grand Challenges – is a key asset.
- **Large-scale research infrastructures:** PSI, ETH Zurich and EPFL have long-standing expertise and a leading position in planning, implementing and operating large-scale research infrastructures. With specific user and service labs, these institutions provide access to research infrastructures for users from academia and industry. In addition, experts from the ETH Domain contribute significantly to international research infrastructures located in other countries.
- **Knowledge and technology transfer (KTT):** All ETH Domain institutions have established manifold activities and instruments to exploit their research findings and to transfer knowledge and technology to the private as well as the public sector. Among these activities are patenting, licensing, creating spin-offs, consulting and providing expert services, research collaboration with industry and continuous education. With regard to public goods such as environmental quality, natural hazards and natural resources, engagement with public authorities and civil society organisations is particularly relevant. The patent portfolio analysis by BAK Economics AG (cf. Chapter E.2) clearly stresses the high quality of the ETH Domain's patent portfolio by highlighting the fact that one third

"What role does the ETH Domain play in a national context, particularly in the core areas of its basic mandate: teaching, research and knowledge and technology transfer, and in further areas (national tasks, research infrastructure, public relations, etc.)?"

³ Including computer and communication sciences in analogy to the German term MINT (Mathematik, Informatik, Naturwissenschaften, Technik).

of all its patents in 17 technological fields belong to the best 10 % worldwide. Moreover, the ETH Domain institutions significantly contribute at different locations to the “Switzerland Innovation” park. The notion of “KTT through people” is of key importance: knowledge and know-how are transferred into the economy and into the public sector by the highly-qualified graduates of the ETH Domain institutions.

- **National tasks:** Since they are often the only experts in a given field in Switzerland, scientists and institutions of the ETH Domain exercise their particular responsibility by providing high-quality scientific services and infrastructures and by fulfilling numerous tasks of national interest for the benefit of the country.
- **Public relations:** The ETH Domain maintains a dialogue with society and makes scientific findings accessible to a broad audience in a comprehensible manner (e.g. by numerous public events, presence in media) and organises specific activities to arouse interest in the STEM subjects among schoolchildren of both genders. Representatives of the ETH Domain participate in public debates as honest brokers, thus fostering the dialogue of science with stakeholders and with society in general.

Challenges

- **International versus national orientation:** Regarding national coordination of scientific activities (cf. Chapter A.3), keeping the balance between an international orientation and the related global competition on one hand while maintaining a national perspective (incl. fulfilling national tasks) on the other can place heavy demands on the ETH Domain's institutions. Moreover, massive investments in science and higher education by other countries seeking to become world leaders in specific fields pose a challenge for Swiss academic institutions in terms of keeping ahead and maintaining their international standing.
- **Research-based education:** Ensuring high teaching standards while also improving the success rates of bachelor's students remains a challenge, given that student numbers are increasing. In addition, ETH Zurich and EPFL have to cope with differing levels of knowledge among Swiss and international students in their first year of bachelor's studies.
- **High-quality research:** Strengthening and communicating the overriding importance of long-term orientation and continuity in fundamental research remains a challenge. Preserving continuity and allowing for flexibility at the same time in order to swiftly invest in upcoming areas of research is essential but challenging. It is vital that scientists working in Swiss research institutions should have access to international networks and international competitive research funding (notably the European Framework programmes for Research and Innovation as well as the Euratom research and training program). For Switzerland to have only a partial association with or even be excluded from the Framework programmes or Euratom would discriminate against Swiss-based researchers and thus impair Switzerland's scientific excellence.
- **Large-scale research infrastructures:** The current expertise for developing new and operating existing large-scale research infrastructures must be retained within the ETH Domain for the benefit of Switzerland's scientific community and the industry, even though the costs for developing new and upgrading existing infrastructures are increasing.
- **KTT:** The segmentation of political responsibilities in Switzerland as well as complex political processes can slow down the implementation of measures to promote innovation in Switzerland.

A.1.1 Teaching

As specified in the strategic objectives, the ETH Domain offers students an attractive, research-based education at the university level that is first-rate by any international standard. This way, knowledge and expertise are transferred into the economy and the public sector by the highly qualified graduates and the ETH Domain contributes to alleviating the skills shortage⁴ in Switzerland.

- The ETH Domain's unique contribution to the Swiss higher education sector lies in its focus on the STEM fields in which ETH Zurich and EPFL teach increasing numbers of students and doctoral students (cf. Figure 3).

Figure 3: Students and doctoral students at ETH Zurich and EPFL by discipline⁵

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Architecture	2,553	2,743	2,994	3,098	3,177	3,097	3,066	3,060	3,030	3,047
Civil and Geomatic Engineering	1,980	2,170	2,405	2,727	2,900	3,074	2,946	2,882	2,860	2,791
Engineering Sciences	5,081	5,597	5,985	6,391	6,816	7,245	7,502	7,903	8,069	8,398
Information and Communication Technology	1,906	1,929	2,070	2,253	2,367	2,536	2,665	2,809	3,033	3,261
Exact and Natural Sciences	3,671	3,942	4,155	4,476	4,780	4,883	4,944	5,145	5,442	5,595
Human Medicine	–	–	–	–	–	–	–	–	–	99
Life Sciences	2,858	3,034	3,176	3,314	3,708	3,879	3,990	4,051	4,216	4,312
System-oriented Natural Sciences	2,030	2,104	2,205	2,261	2,201	2,159	2,211	2,284	2,411	2,437
Management, Technology and Economics	778	819	859	833	870	897	913	913	972	973
Humanities, Social and Political Sciences	199	202	255	276	268	276	300	310	318	380
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

- In specific STEM fields with high relevance for Swiss industry, education at university level is provided exclusively or predominantly by ETH Zurich and EPFL (cf. Figure 4).

Figure 4: Proportion of STEM-field graduates of Swiss universities trained at ETH Zurich and EPFL (2017)

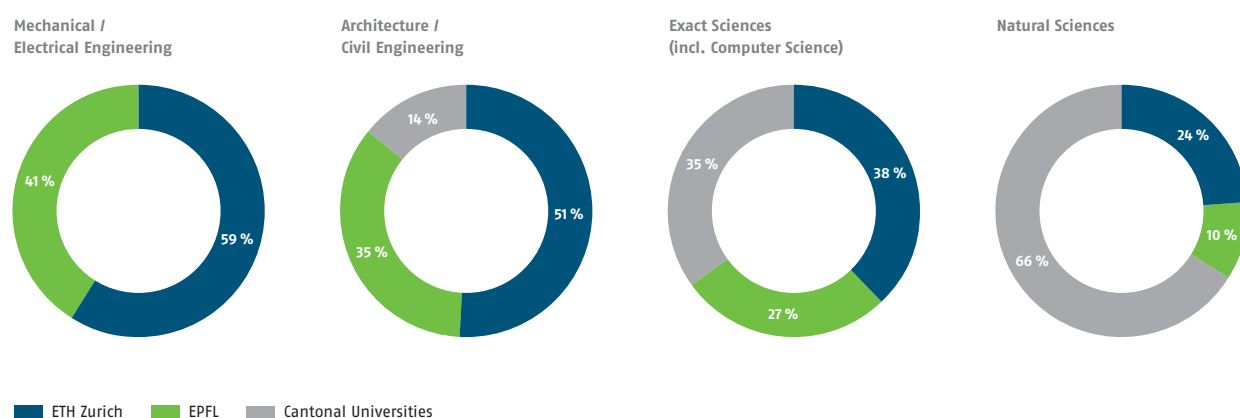


Figure 4 is based on data from the Federal Statistical Office on graduates (master's degree and doctorate) of Swiss universities (cantonal universities, ETH Zurich and EPFL) for 2017.

⁴ E.g. Swiss Skills Shortage Index <http://adecgroup.ch/en/thought-leadership/swiss-skills-shortage-index/>

⁵ Annual Report of the ETH Board on the ETH Domain 2017

- Also, ETH Zurich offers Agricultural and Food Sciences (bachelor's and master's), Health Sciences and Technology (bachelor's), exclusively at the university level. EPFL offers Microengineering and Life Sciences Engineering, with bachelor's and master's programmes, exclusively at the university level.

Medical studies with a strong science background:

- In 2017, ETH Zurich introduced the new bachelor's degree course in Human Medicine. This course offers 100 places, and is aimed at students who are interested in medicine and also in natural sciences and technology. They were required first to pass a medical studies aptitude test set by swissuniversities. Almost 300 applicants put ETH Zurich down as their first choice when they applied to do the aptitude test. For the subsequent Master's in Medicine, students will switch over to one of ETH Zurich's partner universities after three years: University of Zurich, University of Basel and Università della Svizzera Italiana (USI). The set-up of the new Bachelor's degree course was made possible by the good cooperation with various clinical partners and the universities mentioned above.
- In the Life Sciences Engineering bachelor's at EPFL, a one-year gateway programme "passerelle" to the Master's in Medicine programme at the Universities of Lausanne and Geneva has been set up in close collaboration with these universities. This highly selective programme comes in response to the healthcare challenges arising from rapid advances in technology and biology. In particular, specific courses have been introduced and coordinated in the EPFL curriculum to prepare students to succeed in the "passerelle". Ten places were pre-allocated to EPFL students in the "passerelle" for 2018/2019.

Innovative forms of teaching, and teaching initiatives

ETH Zurich has well-established processes to improve teaching and learning. These processes help to keep the curricula up to date and to encourage the development of new teaching forms.

- The focus for the years to come will be on online examinations. These incorporate a large number of examination task forms ranging from short-answer, multiple-choice and drag & drop questions to essay questions. They also provide a secure, controlled environment for authentic, competence-oriented examinations, and for electronic open-book examinations with selective access to certain resources. Currently 200 exams take place online, with approx. 20,000 candidates. Plans envisage an increase to 400 exams with 40,000 candidates from 2022 onwards.

In the following, three examples illustrate the broadness of innovation in teaching.

- E-tutorials: This learning innovation allows students to select a level of detail that matches their needs and to practice programming using example cases. The E-tutorials project plays a key role in essential digital skills training at the undergraduate level, enabling over 800 first year bachelor's students from five departments to familiarise themselves with programming. Lecturers from the Department of Computer Science send the students to a virtual programming laboratory where they solve practical problems from their area of study using real data. This E-tutorial project is a recipient of the 2018 KITE Award, an ETH Zurich prize for outstanding teaching innovations.
- PELE is a Personal Electronic Learning Environment. It allows for individualised learning through gamification and realtime dashboards. Both PELE and E-tutorials use digitalisation to scale-up individualised teaching for large classes.
- The Student Project House is a creative think- and makerspace open to all students at ETH Zurich. In the Student Project House students learn how to identify an actual need, design solutions and test their hypothesis with real prototypes. The space is designed to bring students of different disciplines and expertise levels together.

At EPFL, several innovative education methods and initiatives have been launched to improve teaching and students' learning. They have been organised around three pillars: CORE, MAKE and LEARN.

- Polytechnical skills plays a central role in the education of engineers, architects and researchers. A solid basic knowledge is key to succeed in every discipline. The content of polytechnical lectures has been reviewed, leading to a common and coordinated offering in the first Bachelor year. The CORE initiative supports this evolution by introducing new teaching methods such as flipped classrooms, remote or virtual experiments, Massive Open Online Course (MOOC)-assisted classrooms, etc.
- Once acquired, the basic education has to be contextualised in practical applications depending on the field of studies. The MAKE initiative supports lab experiments and interdisciplinary projects involving students from different faculties. Specific infrastructures are being developed through Discovery Learning Labs (DLL), including room facilities as well as coordinators and experts to guide the students.
- The LEARN Center launched recently focuses on translational research in educational science and pedagogy. That is, to try out new teaching methods, demonstrate their impact and turn them into new teaching practices for EPFL and, where desirable, for the educational system as a whole.

Since the launch of its first MOOC in 2012, EPFL has also built a strong reputation in e-learning. Today, more than 100 MOOCs are available online, and more than 120,000 certificates of successful course completion have been issued to learners around the world. With its unique experience, EPFL's Center for Digital Education is known in Europe as a leader in MOOC production. Since 2018, the Center is also leading the development of the Swiss MOOC Service, a national platform for distributing courses that gives Swiss institutions of higher education an opportunity to get started in the MOOC arena. The huge amount of data produced by online education will serve as basis for the development of learning analytics and learning companions.

Teaching contributions by the research institutes

The interdisciplinary network of competencies of the ETH Domain institutions is a key success factor (cf. Chapter B.2.1) in teaching and provides excellent opportunities for bachelor's, master's and doctoral students. The research institutes, PSI, WSL, Empa and Eawag, complement the teaching of ETH Zurich and EPFL in various ways. They offer courses, seminars and practical workshops and activities, as well as other educational opportunities in disciplines of their specific competencies. In 2017, the commitment of the research institutes' employees in education was equivalent to 18,000 teaching hours. Moreover, the research institutes' wide range of research topics, mainly in the field of applied research, attract many students and doctoral students. In 2017, a record 602 students conducted their bachelor's and master's projects, and over 800 students their doctoral theses, at one of the research institutes.

The following selected examples illustrate the teaching contributions by the research institutes.

- Innovative teaching formats are also used for topics of highest relevance at the research institutes, e.g. related to large-scale research facilities at PSI. A MOOC entitled "Introduction to synchrotrons and X-ray free electron lasers (SYNCHROTRONx)" was developed in 2018 and is offered in addition to lectures on these topics at EPFL. The course provides valuable insights into the broad spectrum of scientific disciplines, from the generation of X-rays via a description of the machines to modern experiments performed using these facilities. More than 4000 students have enrolled for this MOOC – a great success for the first round.

- Specialised Master's Programme in Nuclear Engineering (since 2008): the first master's programme with a degree certificate jointly issued by ETH Zurich and EPFL. Teaching is provided by the Department of Mechanical and Process Engineering at ETH Zurich and the EPFL's School of Basic Sciences, Physics Section. PSI contributes to the programme by offering supervision and scientific infrastructure for semester projects and master's theses as well as by providing additional lecturers in specific academic fields.
- WSL supports ETH Zurich substantially in offering an attractive Major in Forest and Landscape Management (Environmental Sciences Master's Programme): Almost half of the courses are taught by WSL researchers and cover topics that are not in ETH Zurich's research portfolio but are important for the students' curricula.
- Empa researchers teach at several summer schools; e.g. the ECE Summer School "Energy Systems in Transition and Sustainable Mobility" (ETH Zurich, PSI and several Swiss universities) or the CCMX Summer School "Characterisation of Materials" (ETH Zurich, EPFL, PSI and others). Other platforms for knowledge transfer with institutions of the ETH Domain include forum-vera ("Digitalisierung – Energie – Entsorgung") and the Swissmem Executive Seminar.
- In collaboration with EPFL, Eawag's Department of Sanitation, Water and Solid Waste for Development (Sandec) has developed a 4-course MOOC series on Water, Sanitation and Hygiene (WaSH). At the end of 2017, EPFL launched a new MOOC in collaboration with Eawag's Sandec Department and the International Committee of the Red Cross (ICRC); this course is an introduction to public health engineering in a humanitarian context.
- Eawag has a number of joint professors with ETH Zurich and EPFL (cf. Chapter A.4) in specific areas such as urban water management, molecular microbial ecology, aquatic ecology, physics of aquatic systems, and water quality and treatment. The joint professors are heads of departments or groups at Eawag and two are additionally members of the Directorate.

A.1.2 Research

The ETH Domain institutions perform fundamental research on a world-class level. This capacity is essential for the ETH Domain's contribution to Switzerland's innovative power, as fundamental research has always been the most important source of ground-breaking innovation and is therefore crucial for fostering the country's innovative capacity in the long-term.

The excellent research performance of the ETH Domain institutions puts them high up in the national and international rankings, as demonstrated by academic indicators (e.g. bibliometric analyses, university rankings) and by the regular evaluations of individual institutions and their constituent units.

Bibliometric analysis (cf. Chapter D)

As requested in the mandate for the 2019 Intermediate Evaluation of the ETH Domain, the ETH Board commissioned a bibliometric analysis. The analysis was carried out by the Center for Science and Technology Studies (CWTS) at Leiden University, the Netherlands. CWTS's methodology offers a variety of indicators, aimed at measuring the scientific output of a particular institution as well as the impact of the publications it produces. In addition, CWTS also assesses scientific cooperation patterns. The results, presented in Chapter D of this report, confirm the excellent performance of the ETH Domain institutions in terms of publication activities. There has indeed been a constant increase in both the output and the impact of the institutions' publications. This was achieved despite the already very high performance depicted by the previous bibliometric analyses. In the vast majority of the institutions' most active research fields, the impact of the publications is high. The values of the most important impact indicators are always larger – and sometimes significantly larger – than the world average.

University Rankings (cf. Appendix A.1)

ETH Zurich and EPFL hold top positions in the international rankings of universities based on performance indicators of research and teaching and academic reputation.

- ETH Zurich is ranked 11th in the Times Higher Education (THE) World Ranking and 7th in the QS World Ranking.
- EPFL is ranked 2nd in the Times Higher Education (THE) Young University Ranking (universities that are up to 50 years old) and 22th in the QS World Ranking.

ERC Grants (cf. Appendix A.1)

The researchers at the ETH Domain institutions are very successful in competing for the prestigious ERC (European Research Council) grants and have thus contributed greatly to Switzerland achieving its 5th place in Europe. The ETH Domain's share of the ERC grants acquired by researchers at institutions in Switzerland between 2007 and 2016 was 51 % (530 ERC grants for Switzerland, thereof 269 ERC grants for the ETH Domain).

In specific research fields, e.g. energy and digitalisation, the ETH Domain has a leading and coordinating role in Switzerland.

Energy Research (cf. Chapter C.1)

The ETH Domain is regarded as the centre of excellence for energy research: world-leading multidisciplinary research is carried out here to develop methodologies and technologies that address the challenges of the Swiss Energy Strategy and beyond which cannot be done by the sector itself. Furthermore, ETH Domain institutions were nominated as leading houses for seven of the eight Swiss Competence Centers for Energy Research (SCCERs), which are financed by Innosuisse.

Digitalisation (cf. Chapter C.2)

The institutions of the ETH Domain collectively not only have a long tradition of world-class research and teaching in the foundational areas of digitalisation but are also actively applying this technology to areas of societal interest. Individual efforts are complemented by major joint teaching, research and technology transfer activities.

For example, ETH Zurich and EPFL are leading institutions in areas such as machine learning, data science, information theory, programming languages, software engineering, image processing, computer architecture, computer networking, computer graphics, and security. At the same time, both institutions have successfully applied digitalisation to other sciences through interdisciplinary research in medical and health sciences, digital humanities, digital fabrication, robotics, energy science, environmental science, and architecture. This process will continue as data-driven research, including novel simulation technologies, infuses natural sciences with new models and methods.

The research institutes have invested considerably and are further developing and applying digitalisation to important domains. Notable projects are the smart home "NEST" (cf. Chapter A.4.2), which is jointly operated by Empa and Eawag; environmental monitoring using distributed sensor networks at Empa, Eawag and WSL; mobility of the future at Empa; the Energy System Integration (ESI) platform by PSI (cf. Chapter A.4.2); and upgrades of the large-scale research facilities of the ETH Domain at PSI, such as SLS 2.0.

The key role of ETH Zurich and EPFL in ICT research⁶ in Switzerland is clearly demonstrated by the high proportion of publications assigned to their institutions. Depending on the specific research fields, ETH Zurich and EPFL account for between 60 % and 70 % of all Swiss publications (cf. Figure. 11, Appendix A.1).

⁶ SBFI, Herausforderungen der Digitalisierung für die Bildung und Forschung in der Schweiz, Juli 2017

A.1.3 Research Infrastructures

The ETH Domain has a specific responsibility for, and plays a leading role in, developing new – and operating and upgrading existing – research infrastructures of national importance, as set out in the Federal Council's Strategic Objectives for the ETH Domain as well as the Swiss Roadmap for Research Infrastructures⁷. The ETH Domain institutions devote considerable financial resources to ensuring the state-of-the-art performance, long-term operation and further development of the large-scale research facilities for the national and international scientific community or for industry users. Major upgrades of these facilities are planned in a timely and coordinated manner so that Switzerland remains internationally competitive and retains its excellent global position in this field.

For an overview of the national large-scale research infrastructures of the ETH Domain, see Figure 12, Appendix A.1. In addition to these research infrastructures there are various centres and platforms for the joint use of instruments and equipment by institutions within and outside the ETH Domain.

Prioritised research infrastructures 2017–2020

In the period 2017–2020, the ETH Board, based on its Strategic Planning, prioritises four research infrastructures: the Sustained Scientific User Lab for Simulation Based Science at the Swiss National Supercomputing Centre (CSCS) of ETH Zurich, the Blue Brain Project at EPFL, the ATHOS beamline at the X-ray free-electron laser SwissFEL at PSI, and the upgrade of the CMS detector at CERN under the direction of ETH Zurich.

Swiss National Supercomputing Centre

The Swiss National Supercomputing Centre (CSCS) develops – and provides the key supercomputing capabilities required to solve important problems of science and/or society. The Centre enables world-class research with a scientific user lab that is available to Swiss and international researchers through a transparent, peer-reviewed allocation process. CSCS's resources are open to academia but are also available to users from industry and business. The CSCS computing systems are used for a diverse range of purposes – from high-resolution simulations to the analysis of complex data. CSCS is currently a major driving force in the European Partnership for Advanced Computing (PRACE). Through its engagement as a base infrastructure provider in the Human Brain Project (HBP), CSCS has played a seminal role in defining the federated data and computer services that form the basis of a scalable European data infrastructure.

Blue Brain Project

The Blue Brain Project (BBP) is pioneering simulation neuroscience to address the big data challenge in neuroscience. This requires a unique organisational structure with a mission-driven agenda and tight co-design between science and engineering. BBP has built an unparalleled ecosystem of scientific workflows, software and hardware for simulation neuroscience. It created the European Human Brain Project (HBP) and inspired other large-scale brain initiatives. The ecosystem is the foundation of several HBP platforms enabling others to accelerate their science. BBP's methods and science have been publicly released in over 100 papers, more than 25 open source software tools and over 1000 computational models. BBP developed the "Collaboratory" that drives community science in HBP. It also contributes to new community standards, employs online courses to teach simulation neuroscience, and has begun with public outreach and translation to industry.

⁷ SERI, Swiss Roadmap for Research Infrastructures 2015; <https://www.sbfli.admin.ch/sbfli/en/home/research-and-innovation/research-and-innovation-in-switzerland/swiss-roadmap-for-research-infrastructure.html>

ATHOS beamline at SwissFEL

X-ray free-electron lasers (XFELs) are a new generation of light sources offering novel experimental capabilities by providing very intense and tightly focused beams of x-rays with pulses as short as 10 femtoseconds and wavelengths down to 0.1 nanometers – essential parameters for the investigation of ultrafast dynamic processes in atomic and molecular structures. Phase I of the SwissFEL project was focused on the construction of the accelerator complex and the hard x-ray beamline ARAMIS. Since the official opening of SwissFEL at the end of 2016, several groundbreaking pilot experiments at ARAMIS were performed. Regular user operation will start in spring 2019, with the first user call in autumn 2018.

Phase II of the project – the ATHOS beamline – will double the scientific capacity of SwissFEL and will expand the capabilities to soft x-rays. This energy region will allow detailed investigations of lighter elements – e.g. oxygen, carbon and nitrogen – and play an important role in many chemical and biological processes as well as in transition metals, which are prominent components of quantum devices. Beamline component development, procurement and construction of the ATHOS beam line started in 2017. First light from ATHOS is expected in the second half of 2019.

CMS at CERN

The CMS Experiment operating at the Large Hadron Collider (LHC) at CERN is a general-purpose detector addressing fundamental physics questions concerning the structure of the universe. The ETH Domain has made highly visible contributions to the construction of the detector. The CMS groups at ETH Zurich and PSI have held the technological lead in the design and construction of the electromagnetic calorimeter and the pixel detector. Many questions still remain for the LHC programme at CERN to address. To this end, the LHC experiments will be upgraded in 2024–26. The strategic ETH Domain funds for the CMS upgrade will enable the involved groups to contribute significantly to this upgrade and retain their leadership roles.

Swiss Roadmap for Research Infrastructures

The update of the Swiss Roadmap for Research Infrastructures, prepared in view of the ERI Dispatch 2017–2020, demonstrates the ETH Domain's key role. Six new – or substantial upgrades of existing – research infrastructures, which were positively evaluated by the SNSF and included in the 2015 Roadmap, are being implemented. In view of the ERI Dispatch 2021–2024, the 2019 update of the Roadmap is ongoing as described in the SERI guideline⁸. The ETH Domain institutions submitted three new research infrastructures and three substantial upgrades of existing ones for the Roadmap process (for ETH Domain internal procedures see Chapter A.3.3). The research infrastructures were evaluated scientifically by the SNSF, and – in terms of implementation and funding – by the ETH Board. Based on the principles of scientific excellence, the ETH Board decided to include the following three research infrastructures in the 2019 Swiss Roadmap for Research Infrastructure and the Strategic Planning 2021–2024 of the ETH Board for the ETH Domain:

- HPCN-24 at the Swiss National Supercomputing Centre (CSCS) of ETH Zurich (substantial upgrade of HPCN-20);
- SLS 2.0 (substantial upgrade of the Swiss Light Source SLS at PSI); and
- Catalysis Hub (a new research infrastructure at ETH Zurich and EPFL).

⁸ German https://www.sbf.admin.ch/dam/sbf/en/dokumente/2017/03/ch-roadmap-2019.pdf.download.pdf/170308_Leitfaden_Roadmap_2019_SBF_DE.pdf; French https://www.sbf.admin.ch/dam/sbf/fr/dokumente/2017/03/ch-roadmap-2019.pdf.download.pdf/170308_Leitfaden_Roadmap_2019_SBF_FR.pdf

International research infrastructures

The ETH Domain institutions play a leading role internationally with regard to the conceptualisation, development and operation of world-class research infrastructures. They not only host and develop large-scale research infrastructures in Switzerland (cf. Figure 12), but also contribute decisively to the development of such infrastructures at many places in international consortia. In such endeavours (e.g. European Spallation Source ESS⁹, ITER¹⁰, Large Hadron Collider LHC¹¹, European XFEL¹²), representatives of ETH Domain institutions are sought-after experts. The embedding of the ETH Domain institutions in international networks allows for an efficient distribution of tasks and profiles among the international infrastructures – for instance in the field of high-performance computing – which enhances their effective use.

A.1.4 Knowledge and Technology Transfer (KTT)

In order to reinforce Switzerland's innovative strength and competitiveness, the ETH Domain promotes collaboration and exchange with industry and society. To present a comprehensive picture of the ETH Domain institutions' contribution to innovation in Switzerland, it is important to adopt a broad concept of knowledge and technology transfer (KTT). This includes knowledge transfer regarding public goods to public and private actors as well as knowledge and technology transfer to industry. Graduates of the ETH Domain are also important players of knowledge transfer in Switzerland and abroad.

The key figures for the ETH Domain's KTT activities are presented in Figures 5 and 6, and encompass the number of patents, licences, spin-offs and cooperation agreements.

Figure 5: Knowledge and technology transfer in the ETH Domain¹³

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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

⁹ www.europeanspallationsource.se/about

¹⁰ www.iter.org/proj/inafewlines

¹¹ www.home.cern/topics/large-hadron-collider

¹² www.xfel.eu

¹³ Annual Report of the ETH Board on the ETH Domain 2017

Figure 6: Cooperation with the private and the Swiss public sector¹³

	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 Swiss public sector	285
ETH Zurich	88
EPFL	54
Research Institutes	143

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

Patent portfolio analysis (cf. Chapter E.2)

The patent portfolio of the ETH Domain was recently analysed in depth in a study conducted by BAK Economics AG. Using a new methodology facilitating evaluation of the quality of patents (and not just their number), the analysis compared the ETH Domain with other research institutions and the industry sector in Switzerland as well as with a selection of leading international research institutions. Seventeen technologies were considered, covering two thirds of the total ETH Domain patent portfolio. The results of this study, presented in Chapter E.2 of this report, show that the ETH Domain's patent portfolio is of above average quality and that one third of its patents are world class patents (i.e. among the 10 % highest rated worldwide). The national comparison indicates that the ETH Domain ranks in first place in eight out of 17 technologies and in the top five in six additional technologies. The international comparison further shows it to be among the leaders in more than one third of all technologies analysed. The ETH Domain is positioned ahead of the European institutions considered in the study, but behind those in the USA.

Collaboration with industry

Collaboration with business, and in particular with industry, represents an important aspect of KTT at all ETH Domain institutions. On the level of the individual institutions, numerous activities and achievements are related to collaboration with industry. The examples below focus on new aspects of industry innovation; each institution presents a success story in this regard in Appendix A.1.

- In the last two years, ETH Zurich has significantly expanded its communication activities with industry and strengthened the Industry Relations team. Besides the well-established, yearly Industry Day that attracts more than 600 participants, a news channel "ETH News for Industry"¹⁴ has been built up. The news and videos provide information about industry-relevant ETH projects and technologies. News is already shared via newsletter with more than 1200 subscribers and additionally on the social media platform LinkedIn. The new website "Info for SMEs" not only provides information on how to collaborate with the institution, but also showcases real-life cases in interviews and videos. The Industry Relations team supports companies in finding research partners and organises tailor-made lab tours and visits to research groups once the expertise sought is identified.

¹⁴ <https://www.ethz.ch/en/industry-and-society/industry-relations/news-for-industry.html>

- The success stories on “ETH News for Industry” demonstrate the broad range of ETH Zurich’s collaboration with industry. The news stories cover projects with small companies, such as the key manufacturer Urban Alps (the video shows how ETH researchers develop design tools and 3D printing processes), as well as projects with large companies, e.g. Swiss International Airlines (the video shows how ETH researchers help to improve pilot training).
- The OpenLab of the Zurich Information Security & Privacy Centre (ZISC) is a collaboration space where industry partners can work together with ZISC researchers and the ETH Zurich faculty. ZISC OpenLab was launched in December 2016 and is located right at the heart of the Computer Science Department of ETH Zurich.
- ETH Zurich and the ETH Zurich Foundation have introduced “Partnership Councils” in several fields, such as Energy, Materials & Processes, World Food, Digital/Sustainable Construction, Risk and Mobility. Members represent foundations and industry partners who provide significant financial support for projects and programmes through the ETH Foundation and are interested in playing an active role in building joint initiatives.
- ETH Zurich has started to close the gap between its spin-offs and the corporate world. With a new initiative – Innovation Days – companies define their areas of interest and ETH Zurich proposes a longlist of spin-offs that fall into that category. In several discussions between ETH and the company concerned, a shortlist of spin-offs is defined, all of which are invited to present themselves to the company’s board members and to the innovation and/or corporate venture specialists. Based on a thorough selection, 6–10 spin-offs from the respective field are given an excellent opportunity for potential collaborations and/or corporate investments by presenting their technology and business case.
- Thanks to its Digital Lab being located in the EPFL Innovation Park since mid-2016, the partnership with Swisscom has been particularly successful during the last two years. Recently, Swisscom has funded more than 10 research projects and more than 40 master projects. Swisscom also contributed to several EPFL events, co-organised four events together with EPFL and regularly hosts meetups at its Digital Lab. In addition, Swisscom provided significant support for the Swiss EdTech Collider. Thanks to all of these collaborations and events, Swisscom greatly increased its visibility within the EPFL ecosystem, and is considered one of EPFL’s strategic partners. EPFL is honoured to be a preferred academic partner for which Swisscom funds research projects for at least CHF 1m per year.
- New SMEs offerings: In 2018, the Vice Presidency of Innovation organised FORUM FORWARD, the first large-scale innovation forum on EPFL’s campus entirely dedicated to SMEs. The first staging of the event focused on digital transformation and brought together more than 950 participants from SMEs across the entire country.
- EPFL Innovation Park: In 2018, EPFL Innovation Park hosted four new innovation cells from the following corporate companies: Firmenich, Schindler, Mason Motor and Rollomatic. In total, EPFL Innovation Park currently hosts more than 25 companies and more than 120 start-ups, and it is currently incubating more than 75 new venture projects. Overall, more than 2300 collaborators are located at EPFL Innovation Park. Its current occupancy rate is 99 %.
- In a collaborative study, researchers from PSI, together with engineers from the technology company ABB as well as scientists from the ABB Corporate Research Centre, have investigated high-performance components made from ceramic materials. The ceramics in question are voltage-dependent resistors used in overvoltage protectors, e.g. in electrical transmission lines. Thanks to the well-established neutron imaging technology – a method which, within Switzerland, only exists at PSI – it was possible to examine material changes in the ceramics during the production process. With the results of the study, ABB established a crucial basis for launching a production increase while maintaining the quality of the ceramic components.

- Bridging academic science and industrial needs is one central point in Empa's mission. Empa therefore maintains a broad and intensive exchange with industry. This takes the form of research projects, with an average of 300 ongoing projects, workshops, seminars and training courses and more than 3000 industrial participants annually. Due to Empa's extensive experience in collaboration with industry, the crucial areas of knowledge and technology transfer are known, in particular in material science and development. The biggest obstacle is up-scaling from laboratory scale to industrial production level. Often there is a lack of suitable infrastructure, which is expensive and very costly to operate.

Knowledge transfer to the public sector

Due to their particular role and their specific tasks, the ETH Domain institutions also contribute significantly to knowledge transfer to the public sector (federal, cantonal and local authorities) or to (professional) associations; this in turn may stimulate innovation, for instance with regard to practical problems in environmental management. Given their specific roles, some of the research institutes contribute mostly in this way to innovation in Switzerland. The ETH Domain institutions are important partners for the Federal Offices (e.g. in energy, environment, transportation, public health, etc.), and also for the cantons. Their experienced research staff also act as consistent partners for practitioners and stakeholders, providing independent expert opinions – as illustrated by the following examples.

- Example of collaboration and knowledge transfer between ETH Zurich and the public sector: the newly founded Immigration Policy Lab, a joint venture between ETH Zurich and the Stanford University, has been working with the Swiss State Secretariat for Migration on the use of artificial intelligence to boost refugee integration. Beginning in autumn 2018, the State Secretariat for Migration will be piloting a new, data-driven method for assigning asylum seekers to cantons across the country. Asylum seekers in the pilot programme will be assessed by an algorithm designed to maximise their chances of finding a job. The algorithm will allow officials to send individuals to the canton that best fits their profile, rather than allocate them randomly, as under the current system. The programme will then follow these asylum seekers over the next several years, comparing their employment rates to those of others who entered the country at the same time under the current random allocation system. The test phase will include two thousand people, half placed in cantons with the guidance of the algorithm and half placed randomly. The algorithm's recommendations take into account constraints such as the limited space in a canton, and placement officials make the final decision in each case.
- The Mobility Lab Sion-Valais is a consortium, composed of EPFL, University of Applied Sciences and Arts Western Switzerland, Swiss Post, the Canton of Valais and the City of Sion, that aims at promoting open innovation in the field of mobility and at demonstrating innovative mobility solutions by conducting real-scale trials in the Valais area with strong support from local authorities. Its "SmartShuttles" flagship project, which has operated self-driving shuttles in the old town of Sion since June 2016, was expanded in late 2017 by extending its route as far as the railway station. The link to the station doubled the distance travelled and made it a regular service, with self-driving shuttles serving a railway station for the first time in the world. The extended route between the old town and the station also allows the self-driving shuttles to be tested on roads with a higher traffic volume. On the road next to the station, the SmartShuttles communicate in real-time with traffic lights.

- The research programme “Forests and Climate Change” (2009–2018) has been a joint effort by WSL and the Federal Office for the Environment (FOEN). The programme’s outcomes – presented in a book, a leaflet series, and articles in professional journals as well as at outreach conferences – are essential for forest stakeholders to evaluate risks and chances due to climate change and take appropriate action. The results of this programme provide a foundation for the federal strategy for forest and forest management as components of the national climate change adaptation strategy. Moreover, they support the political implementation of the federal “Forest policy 2020”.
- As part of a collaboration with aircraft servicing firm SR Technics and the Swiss Federal Office of Civil Aviation (FOCA), a team of Empa researchers established the first international measurement standard for aircraft emissions. Empa’s measuring method was approved by the Environmental Committee of the International Civil Aviation Organization (ICAO) in Montreal. It is expected to be ratified by all member states by 2019, and as of 2020 all newly built aircraft engines are to be certified in accordance with this novel standard. From then on, the exact number and mass of fine particles will be registered. Based on this data, the emission regulations can be adjusted at a later date.
- As of September 2017, new emissions regulations for passenger vehicles came into force in the EU and in Switzerland, which made real-world emission measurements in actual road traffic mandatory for the approval of new vehicle types. The new emission-measuring method, designated the “worldwide light duty vehicle test procedure” (WLTP) and replacing the previous technique for type-testing passenger vehicles that dated from the 1970s, had been developed by international workgroups including experts from Empa, the Swiss Federal Office for the Environment (FOEN), the Federal Roads Office (FEDRO) and Bern University of Applied Sciences under the umbrella of the UN’s Economic Commission for Europe.
- Micropollutants are organic trace substances derived from products used in private households, industry and agriculture, such as medicines, body-care products and protective agents for plants and materials. They pollute sources of drinking water and become a critical hazard for ecosystems. Conventional water purification methods cannot completely remove all micropollutants. Eawag has undertaken a wide range of measures in cooperation with the Eawag-EPFL Centre for Applied Ecotoxicology. The network, built up over decades by the waste-water treatment plant operators, the Federal Office of the Environment (FOEN), the cantons and the Swiss Water Association (VSA), has contributed greatly to working out solutions.

A.1.5 National Tasks

The ETH Domain fulfils numerous tasks of national interest, serving the economy, society and the environment. Often the sole experts in Switzerland, the ETH Domain meets its responsibility by providing scientific services and infrastructures of national interest. Benefiting decisively from their close proximity to research, these services are of key importance for Switzerland and are of high quality.

Examples in the fields of economy, health and environment are briefly described here. For a list of national tasks, please see Figure 13, Appendix A.1.

ETH Zurich – KOF Swiss Economic Institute

The Swiss Economic Institute KOF delivers profound insights into the field of economic research. In addition to conducting surveys in all branches of the Swiss economy, it also creates forecasts and indicators for business cycle analysis. KOF's data pool of business surveys is unique in Switzerland. KOF uses these data sets to mirror the business situation of – and sentiment among – Swiss companies by way of indicators. The KOF Economic Barometer, KOF Employment Indicator, KOF Business Situation, etc., are crucial for assessing economic developments in Switzerland. Many of these surveys are carried out monthly and results are evaluated quarterly to be presented to the public. KOF also analyses innovation at Swiss companies, provides studies on health issues and comments on current economic developments.

PSI – Center for Proton Therapy

Patient treatment at PSI has a long tradition. Ever since 1984, patients with certain types of cancer have been able to benefit from treatment with proton beams. The world's first compact scanning gantry for the irradiation of deep-seated tumours with a proton beam is operated by the Center for Proton Therapy (CPT) at PSI. The so-called spot-scanning technique developed at PSI in the 1990s has made it possible to irradiate malignant tumours situated deep inside in the body with extremely high precision and to successfully halt their growth while sparing the healthy tissues surrounding the target. Beside patient treatment, continuous research into and further development of the technology and the innovative treatment concepts are another goal of CPT in close collaboration with various Swiss hospitals and industry partners. The achievement of this goal is greatly enhanced by CPT's unique position: it is embedded in the infrastructure of PSI as Switzerland's largest research institute for natural and engineering sciences. The Center is the only place in Switzerland where patients can receive proton therapy.

WSL – Avalanche warnings

Avalanches are among the most significant natural hazards in the Swiss mountains. WSL/SLF has been responsible for providing an avalanche warning service on behalf of the Swiss federal government since 1945 and informs the public about the current snow and avalanche situation. Its most important service is the avalanche bulletin it issues twice a day in winter. This is a vital planning and decision-making tool for local avalanche and safety authorities and for snow sports enthusiasts, and contributes significantly to preventing avalanche-related accidents in villages or along transport routes.

Eawag, EPFL – Swiss Centre for Applied Ecotoxicology

As more and more anthropogenic chemicals are released into the environment, it is increasingly important to understand their effects on ecosystems. Since 2008, the Eawag-EPFL Centre for Applied Ecotoxicology has been investigating how chemicals affect the environment, developing methods for their evaluation and passing on its expert knowledge to practitioners through consulting and continuing education. It forms a bridge between research and practice and is an important partner of Swiss agencies. As such, it has contributed to the scientific evidence leading to new environmental legislation such as that requiring the upgrading of Swiss wastewater treatment plants to remove micropollutants, and the implementation of effect-based water quality criteria for micropollutants. It is currently developing a methodology to assess the quality of sediments, and will contribute to the implementation of the Swiss Action Plan for Plant Protection Products.

A.1.6 Public Relations

The ETH Domain maintains its dialogue with the general public in a variety of ways and receives excellent feedback. On the one hand, dialogue with society at large 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 engage in 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. The ETH Domain is particularly keen to engage with the general public on the major challenges of our age, such as digitalisation, climate change and personalised health. The ETH Domain can make decisive contributions to address these challenges. Selected examples of activities to strengthen the dialogue with society are presented in the Annual Report of the ETH Board on the ETH Domain¹⁵.

The ETH Board has recently reinforced its communication strategy to foster and intensify the dialogue with public authorities, politicians and society and, more generally, to promote understanding of the functioning of science and institutions of the higher education sector in politics and society (cf. Chapter F, Recommendation 9).

¹⁵ Annual Report of the ETH Board on the ETH Domain 2017, Strategic Objective 7: Role in society and national tasks

Appendix A.1

University Rankings

Figure 7: Ranking of ETH Zurich and EPFL according to the THE, QS, ARWU and CWTS Leiden Rankings in 2018

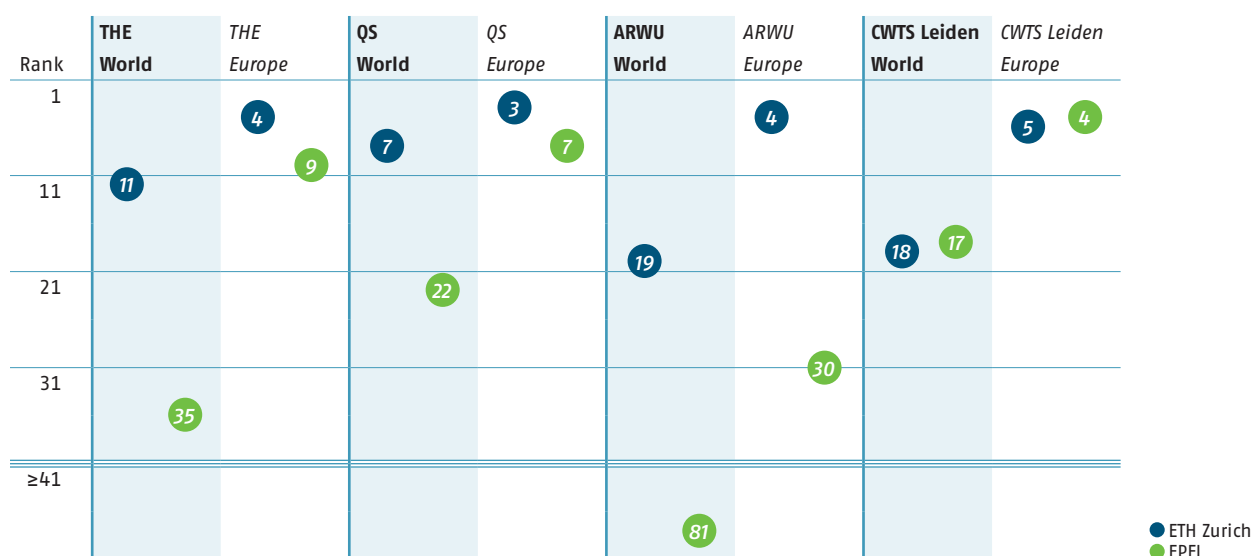
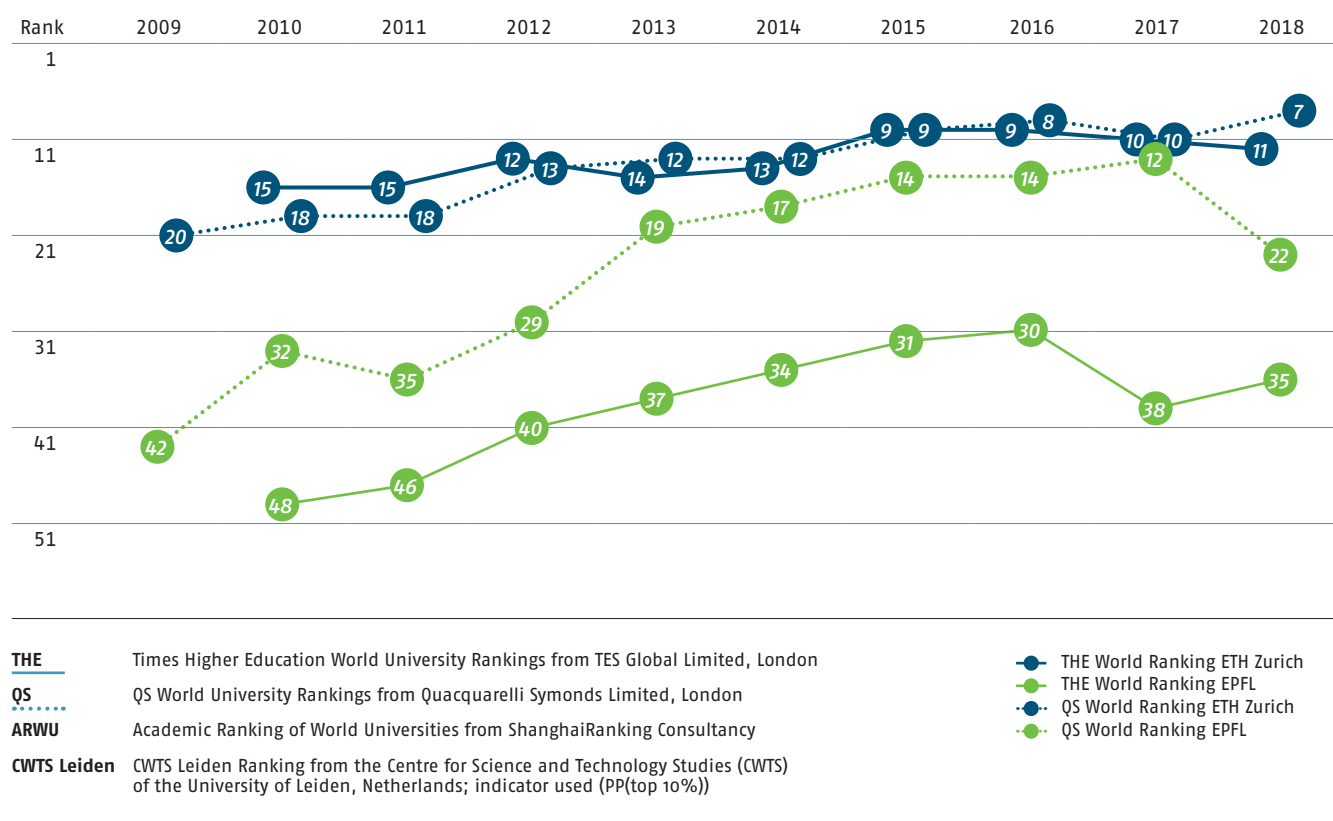


Figure 8: Ranking of ETH Zurich and EPFL according to the THE and QS World Rankings from 2009 to 2018

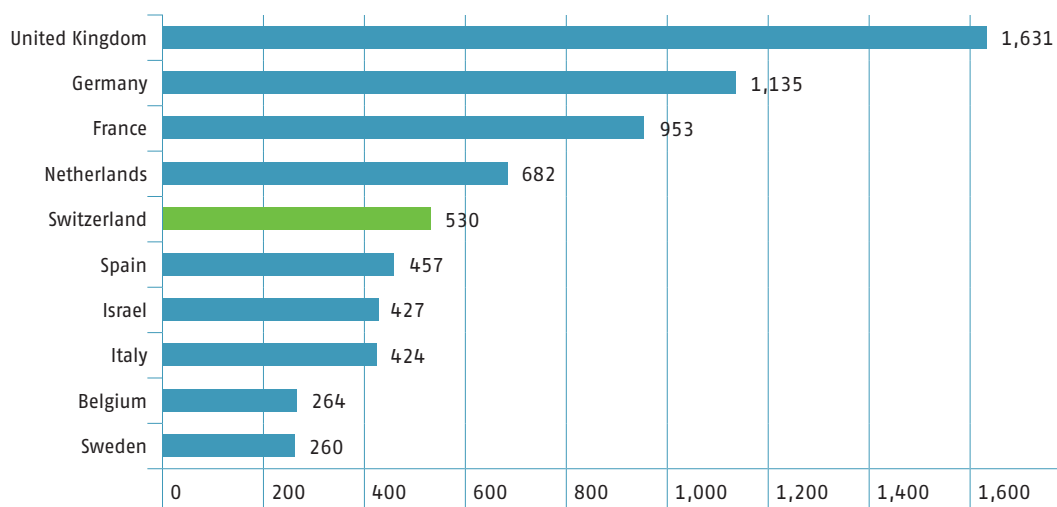


ERC Grants¹⁶

The European Research Council (ERC) has been funding basic research in Europe since 2007 by awarding ERC grants. The selection of the recipients 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 reputation of the researchers and of the institutions where the research is carried out. Over the ten-year period, more than 7000 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.

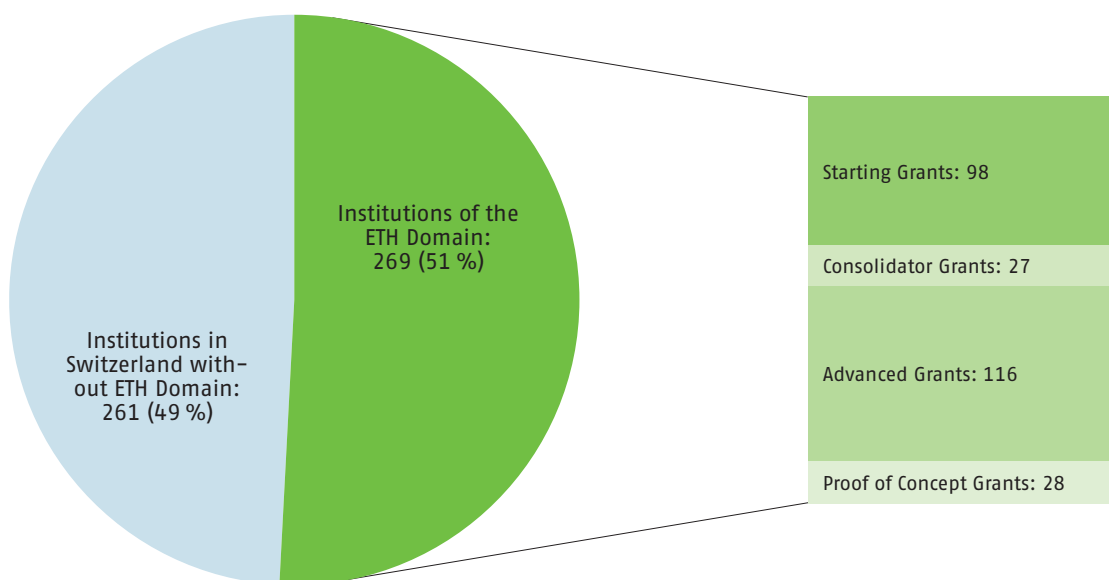
Researchers at institutions in Switzerland have been very successful in their bids for ERC grant funding since 2007 and had managed to secure a total of 530 ERC grants by 2016. This makes Switzerland the fifth most successful country, after the United Kingdom, Germany, France and the Netherlands (Figure 9). The ETH Domain accounted for over half of the ERC grants that were acquired by researchers at institutions in Switzerland (Figure 10). These 269 ERC grants were made up of 98 Starting, 27 Consolidator, 116 Advanced and 28 Proof of Concept Grants.

Figure 9: The ten countries most successful at acquiring ERC grants from 2007 to 2016



¹⁶ Annual Report of the ETH Board on the ETH Domain 2017

Figure 10: ERC grants received by researchers at institutions in Switzerland from 2007 to 2016 – ETH Domain's share



Figures 9 and 10 are based on data quoted on the website <https://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.

Due to the adoption of 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 SNSF's Temporary Backup Schemes made it possible to bridge the temporary exclusion. The grants in the Temporary Backup Schemes are not included in Figures 9 and 10, but are mentioned in the text.

ICT Publications

Figure 11: Share of ETH Zurich and EPFL at the total number of publications in three research fields (2009–2013)

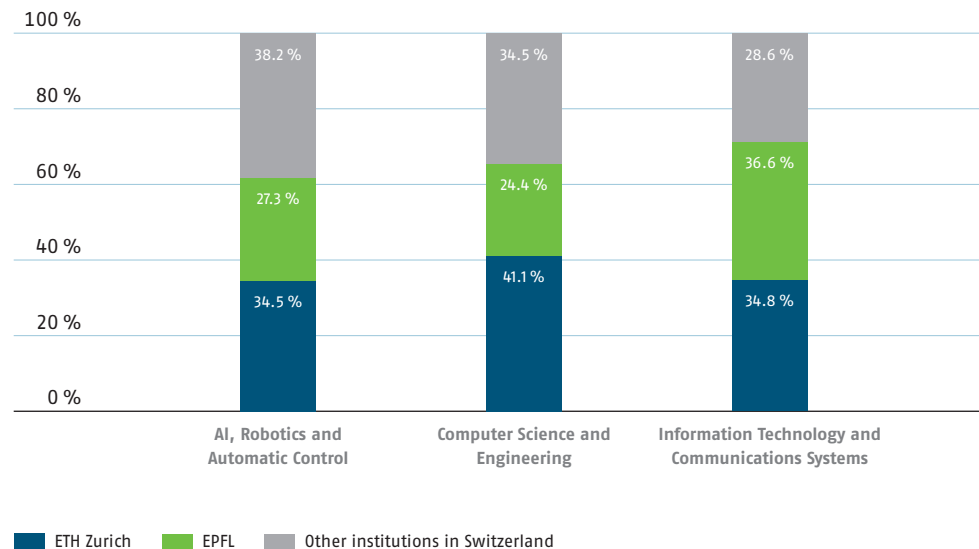


Figure 11 shows the analysis by the SERI based on Science Citation Index (SCI), Social Science Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI) by Thomson Reuters¹⁷.

Success Stories for Collaboration with Industry and the Public Sector

ETH Zurich

ETH Zurich is convinced that technology transfer is no longer a one-way street from academia to industry, but rather an equal exchange whereby both parties are mutually inspired and new visions are jointly materialised to tackle major societal and global challenges. A perfect example are the so-called Lablets, small company research units set up near a university campus. Disney Research Zurich is one such Lablet that just celebrated its 10th anniversary of successful engagement. Research at the Lablet is carried out in close collaboration with ETH Zurich in various research areas such as capture technologies, postproduction video processing for the film industry, human and facial animation for films and computer games, plus sensor technology and robotics. Collectively, the publication output is substantial, more than 400 individual projects were launched and 207 patents have been registered (incl. 89 joint patents of Disney Research Zurich and ETH Zurich). Almost all animated and live-action Disney movies of the last 10 years contained passages made using technologies developed in this collaboration (e.g. Swiss Snowflake). Disney Research Zurich currently has more than 45 employees, plus several doctoral students from ETH Zurich. As a result of this growth, a new facility has been built next to the ETH Zurich campus.

EPFL

Geosatis is a Swiss SME company established in the Canton of Jura which has offices in the EPFL Innovation Park. It offers a secure, reliable, convenient and cost-effective electronic monitoring solution for enhanced public safety and successful offender rehabilitation using Swiss precision, quality and neutrality. Geosatis needed a new generation of antennas for security applications

¹⁷ SBFI, Herausforderungen der Digitalisierung für die Bildung und Forschung in der Schweiz, July 2017

near the human body. With the help of the SMEs group at Vice Presidency for Innovation (VPI), the company applied for an Innosuisse project in collaboration with the Microwave and Antenna Group. Innosuisse experts recognised the quality of the project and approved its funding. Several radio technologies have been studied, such as GPS and cellular communications. The effects of the body on antennas have been minimised at design stage and confirmed in prototype. This research has contributed to the very active field of wearable antennas (WBAN).

PSI

"Switzerland Innovation" parks' site PARK INNOVAARE, located in close proximity to PSI, hosts numerous companies that directly benefit from the large-scale research facilities at PSI and from collaborations with PSI's leading experts in the fields of accelerator technology, advanced materials and processes, humans and health, and energy. Performing research and development under the joint umbrella of PARK INNOVAARE can also stimulate new collaborations between the domiciled companies. In April 2018 leadXpro AG, a pharmaceutical lead discovery company focusing on membrane protein drug targets, and InterAx Biotech AG, a spin-off from ETH Zurich and PSI assisting drug candidate design and selection with a novel systems biology platform, announced they were joining forces to discover and optimise new drug lead molecules targeting G-protein coupled receptors. This collaboration brings together leadXpro's expertise in structure-based drug discovery with InterAx' validated cell-based kinetic signalling assays for compound characterisation.

In July 2018, CERN – the European Organization for Nuclear Research – announced that the newly created Business Incubation Centre (BIC) of CERN Technologies will be set up at PARK INNOVAARE. Start-ups and young high-tech companies with a direct connection to accelerator technology will be supported by a focused funding programme. CERN has operated BICs in nine European countries so far – now also including Switzerland. In addition to CERN as a partner, PSI and the University of Applied Sciences Northwestern Switzerland (FHNW) are also on board to provide companies with advice on technology and management.

WSL

In the field of natural hazards, there is a strong need for process models or tools where both the process and interaction with proposed mitigation measures can be evaluated. RAMMS (Rapid Mass Movements) is a numerical simulation tool developed by WSL, yielding runout distance, flow heights, flow velocities and impact pressure of snow avalanches, rock fall and debris flows. Measurements from the real scale test sites in Vallée de la Sionne (snow avalanches) and Illgraben (debris flows) and data from numerous datasets of historic natural hazard events in Switzerland were used to develop and calibrate the model. Mitigation engineers have applied RAMMS to a wide range of case studies and have established the usability of RAMMS for practical problems. Practitioners and authorities from more than sixty countries use the software for hazard mapping, risk mitigation, planning of streets, settlements and protective measures, and for expert reports after accidents.

Empa

Empa has launched an initiative called Advanced Manufacturing Technology Transfer Centers (AM-TTC) to establish such infrastructures throughout Switzerland as Public Private Partnerships (PPPs). The initiative was included in the Action Plan on Digitalisation. For the development phase (2019–2020) the ETH Board will invest CHF 10m (cf. Appendix C.2). EPFL, PSI and Empa together with their industrial partners have started to establish the first three AM-TTCs.

Eawag

The scope of the “Re-Invent the Toilet Challenge” of the Bill and Melinda Gates Foundation is to bring sustainable and affordable sanitation services to urban slum neighbourhoods in low-income countries. In addition, the toilet should operate grid-free (not be connected to an electricity grid, piped water, or sewer), with total costs not exceeding 5 US cents per person and day. Eawag was awarded a grant and has since successfully developed a holistic sanitation system (“Blue Diversion”) that works across the entire sanitation value chain from capture, storage and transport to reuse of resources. Thanks to a new-generation urine-diverting toilet, undiluted urine, faeces and used flush-and-wash water can be separated. This enables efficient resource recovery, as the used water can be treated in a multi-barrier treatment system and be reused on-site. The resources of the urine and faeces can be recovered off-site, where fertilizers can be produced. In order to ensure safe and reliable disposal of the urine and faeces at an affordable price, the team has also developed a profitable business model that will be interesting for local entrepreneurs.

Research infrastructures

Figure 12: National large-scale research infrastructures of the ETH Domain¹⁸

Acronym	Full name	Lead institution(s) ¹⁹	Location	Website	Brief description
CSCS	Swiss National Supercomputing Centre	ETH Zurich	Lugano	www.cscs.ch	CSCS, the Swiss National Supercomputing Centre, develops and provides the key supercomputing capabilities required to solve important problems for science and/or society. The Centre enables world-class research with a scientific user lab that is available to domestic and international researchers through a transparent, peer-reviewed allocation process.
BBP	Blue Brain Project	EPFL	Geneva	https://bluebrain.epfl.ch/	The goal of the Blue Brain Project is to build biologically detailed digital reconstructions and simulations of the rodent brain, and ultimately the human brain. The supercomputer-based reconstructions and simulations offer a radically new approach for understanding the multilevel structure and function of the brain.
SPC	Swiss Plasma Center ²⁰	EPFL	Lausanne	https://spc.epfl.ch/	The Swiss Plasma Center is one of the world's leading fusion research laboratories. Through a wide range of research programs, all connected to education and training at different levels, SPC works to advance the understanding of the physics of plasmas and develop fusion as an energy source.
SDSC	Swiss Data Science Center ²¹	EPFL, ETH Zurich	Lausanne and Zurich	https://datascience.ch/	The Swiss Data Science Center's mission is to accelerate the use of data science and machine learning techniques within academic disciplines of the ETH Domain, the Swiss academic community at large, and the industrial sector.
SwissFEL	X-ray Free-Electron Laser	PSI	Villigen	www.psi.ch/swissfel	The Swiss X-ray Free-Electron Laser (SwissFEL) is a new generation of light source offering novel experimental capabilities in diverse areas of science by providing very intense and tightly focused beams of x-rays. This novel technology holds exceptional promise for diverse areas of scientific research.
SLS	Swiss Light Source	PSI	Villigen	https://www.psi.ch/sls	The Swiss Light Source (SLS) is a third-generation synchrotron light source which offers quality (high brightness), flexibility (wide wavelength spectrum) and stability (very stable temperature conditions) for applications ranging from fundamental to solid state physics and chemistry, and from materials science to biology, medicine and environmental science.
SINQ	Swiss Spallation Neutron Source	PSI	Villigen	www.psi.ch/sinq	Neutron scattering is one of the most effective ways to obtain information on both the structure and the dynamics of condensed matter. A wide range of problems, from fundamental to solid state physics and chemistry and from materials science to biology, medicine and environmental science, can be investigated with neutrons.
SpS	Swiss Muon Source	PSI	Villigen	www.psi.ch/smus	The Swiss Muon Source is the world's most intense continuous beam muon source. The main advantage of continuous muon beams is the detection of individual muons allowing insights into magnetism and dynamics of materials relevant in physics, chemistry and biology.
NEST	Next Evolution in Sustainable Building Technologies	Empa, Eawag	Dübendorf	https://www.empa.ch/web/nest/overview	NEST accelerates the process of innovation in the building sector. In this modular research and innovation building, new technologies, materials and systems are tested, researched, honed and validated in realistic conditions. The close cooperation with partners from research, industry and the public sector helps to accelerate the launch of innovative building and energy technologies on the market.

National tasks

Figure 13: National tasks of the ETH Domain (non-comprehensive list)

ETH Zurich	Swiss Economic Institute (KOF)
	Swiss Seismological Service (SED)
	Atlas of Switzerland / Swiss World Atlas
	ETH Library, incl. collections and archives
	Conference centres Congressi Stefano Franscini and Villa Garbald
	National Centre for Climate Services (NCCS)
PSI	Center for Proton Therapy (CPT)
	Center for Radiopharmaceutical Sciences (CRS)
	National Competence Center for Nuclear Energy and Safety
WSL	Plant Protection Lab (Biosecurity levels 1–3)
	National forest inventory (LFI)
	Swiss Forest Protection (WSS)
	Long-term Forest Ecosystem Research (LWF)
	Avalanche warning service (avalanche bulletin SLF)
Empa	National Air Pollution Monitoring Network (NABEL)
Eawag / EPFL	Swiss Centre for Applied Ecotoxicology (Ecotox centre)
Eawag	Monitoring of radioactivity in aquatic systems (gamma-ray laboratory)
Eawag / WSL	National Surface Water Quality Monitoring Programme (NAWA)

¹⁸ Based on Swiss Roadmap for Research Infrastructures 2015, Section A; <https://www.sbfi.admin.ch/sbfi/en/home/research-and-innovation/research-and-innovation-in-switzerland/swiss-roadmap-for-research-infrastructures.html>, the Strategic Planning 2017–2020 of the ETH Board for the ETH Domain plus PSI's large-scale research infrastructures.

¹⁹ Indicates only the leading institution(s) of the ETH Domain; for several research infrastructures, partner institutions within and outside the ETH Domain are closely involved.

²⁰ Formerly named Centre de Recherches en Physique des Plasmas (CRPP)

²¹ Formerly named Initiative for Data Science in Switzerland (IDSS)

A.2

Contribution to Economic Development and Attracting Talent

Excerpt from the Mandate:

"To what extent does the ETH Domain contribute to promoting economic development and job creation and attracting companies to set up and increase activities in Switzerland? To what extent does the ETH Domain foster the creation of successful spin-offs? To what extent is the ETH Domain successful in attracting national and international talent (from students to professors), especially women?"

A.2 Contribution to Economic Development and Attracting Talent

Assessment by the ETH Board

Assets

a) Economic development

The ETH Domain is important for Switzerland's economy. Training specialists, providing top-level research and closely cooperating with the private and public sector, the ETH Domain greatly contributes to Switzerland's competitiveness and economic development:

- Thanks to the ETH Domain institutions' close cooperation with other academic institutions both within Switzerland and abroad, their diverse and intensive cooperation with the private sector as well as their active exchange with the public sector, the institutions and their partners ideally contribute to and benefit from the resulting network effects. Thus, the full value of the knowledge exchange exceeds the sum of the individual exchange activities.
- Through a variety of research interactions, the ETH Domain contributes to the innovation capability of SMEs, which is key to their long-term success.
- Institutions of the ETH Domain carry out a wide range of commercialisation activities. These include licensing inventions patented by the institutions themselves (cf. Patent portfolio analysis, Chapter E.2) and supporting the creation of around 50 spin-offs per year.
- The institutions foster the entrepreneurial thinking of their students and staff and provide support for successful spin-off creations.
- With various contributions on different sites, the institutions of the ETH Domain actively contribute to the "Switzerland Innovation" park with the aim of forging even better links between academia and business and offering companies and researchers the best possible innovation-friendly conditions and environment.
- According to a study by the independent consultancy firm BiGGAR Economics, each franc invested in the ETH Domain generates more than five times its value in Switzerland, and each job provided by the ETH Domain supports almost five jobs in total (cf. Chapter E.1).

b) Attracting talents

The excellent international position of the ETH Domain institutions enhances Switzerland's reputation in both academic and economic terms and thus has a positive impact on both the scientific and the economic landscape of Switzerland. The institutions of the ETH Domain contribute significantly to Switzerland's attractiveness and international reputation in the fields of higher education, research and innovation.

- The international reputation of the ETH Domain institutions attracts world-leading scientists and highly talented students, with whom both academic and economic actors can collaborate and who offer their knowledge and skills on the Swiss job market.
- International companies and investors in research and development look for proximity to highly qualified specialists, skills and high performance in research and development. Not least because of the ETH Domain institutions, many of them thus choose to locate to Switzerland.
- The ETH Domain has implemented various programmes and measures to increase the proportion of women on all levels, particular among professors and in other leading positions. To further increase the proportion of women and accelerate progress, the ETH Board adopted the "Gender Strategy 2017–2020: Strategy for Gender Balance and Equal

"To what extent does the ETH Domain contribute to promoting economic development and job creation and attracting companies to set up and increase activities in Switzerland? To what extent does the ETH Domain foster the creation of successful spin-offs? To what extent is the ETH Domain successful in attracting national and international talent (from students to professors), especially women?"

Opportunities for Women and Men" (cf. Appendix A.2). Concrete measures are decided and implemented by the institutions.

Challenges

a) Economic development

- Translating research results into new and sustainable technologies, into practice and policy-making is of growing importance for the competitiveness and innovative capacity of the Swiss economy and the public sector (cf. Chapter A.1.4).
- Training, education and continuing education at all levels are needed to prepare graduates, and members of society in general, for the digital transformation and the labour market of tomorrow ("digital fluency"). The ETH Domain is challenged to respond to the needs of Switzerland by contributing to a sustainable economy and preparing its talents to take on societal challenges of national priority.
- Fostering of entrepreneurship: The ETH Domain institutions must further raise the awareness of their students, faculty and staff of the socio-economic value of research results, and strengthen the various instruments and programmes to stimulate the generation of inventions and novel business ideas.
- All actors in the Swiss academic landscape, including the ETH Board and the ETH Domain institutions, must be even better prepared to demonstrate and communicate why internationality and openness (cf. Chapter B.1) are crucial for the Swiss higher education and research institutions and how the country as a whole benefits from their international competitiveness, economically.

b) Attracting talents

- Attracting national and international talents: The integration of international talents in the institutions as well as in the Swiss society needs special attention. The increasing numbers of students require substantial efforts to ensure the high quality of teaching and education. As a consequence, the attractiveness of the campuses with their infrastructure (e.g. lecture rooms, student housing, refectories) and support services for students need to be secured.
- Increasing the proportion of women, especially at the level of professors, needs increased efforts as excellent women are sought-after around the world.

A.2.1 The Economic Contribution of the ETH Domain

The ETH Domain is an important actor in the Swiss economy. With the education of specialists, its top-level research and close cooperation with business and the public sector, it makes a vital contribution towards Switzerland's competitiveness and the economic development.

According to a study based on 2016 figures conducted by the independent UK consultancy firm BiGGAR Economics, each franc invested in the ETH Domain generates more than five times its value in Switzerland, and each job supports about five jobs. The most important findings are summarised here; more details are available in Chapter E.1.

- With its 21,054 employees, 30,351 students and doctoral students and a budget of CHF 3.5bn, the ETH Domain contributes considerably to Switzerland's economy and society, whether through its training of specialists, investments in research infrastructures, cooperation with SMEs and industry, or through spin-off companies. According to the study, the ETH Domain generated a gross value added (GVA) of CHF 13.3bn. Thus, on the basis of the federal funding

amounting to CHF 2.5bn in 2016, each franc invested in the ETH Domain generated a GVA of over 5 francs in Switzerland. Furthermore, the ETH Domain's 21,054 jobs supported about 98,000 jobs, which means that each job in the ETH Domain supports a total of almost five jobs in Switzerland. It is estimated that, worldwide, the ETH Domain generated a GVA of CHF 16.5bn and supported 123,800 jobs.

- However, the ETH Domain also provides many services which are difficult to quantify financially. In particular, this concerns the field of public goods, i.e. air, water and soil. Thus, research conducted in the ETH Domain contributes to the reduction of air pollution, to better water quality and the avoidance of damage caused by natural hazards; the Swiss Seismological Service and the avalanche bulletin are cases in point. Also, the ETH Domain makes a crucial contribution to Switzerland's good reputation in other countries and to the fact that Switzerland occupies a top position with regard to innovation and competitiveness.
- The services that the ETH Domain provides and the value added that it creates for Switzerland are diverse. Thus, foreign companies settle in its environment in order to profit from specialists and from cooperation with the institutions of the ETH Domain. Prominent examples include Google and Disney in Zurich, as well as Intel and Texas Instruments in Lausanne. These companies create numerous jobs with a high degree of value creation in Switzerland.
- The ETH Domain institutions also create jobs themselves. On average, every week, a spin-off emerges from the ETH Domain. In this way, state-of-the-art products and technologies find their way from research to the market. (Further information is presented in Chapter E.1).

A.2.2 Switzerland Innovation

The "Switzerland Innovation" park²² seeks to sustainably strengthen and promote Switzerland as a competitive international location over the long term. It is jointly supported by the federal government, the cantons and the scientific and business communities. The aim is to forge even better links between academia and business, offer companies and researchers the best possible innovation-friendly conditions, and involve new participants. Five locations have been selected for this purpose, namely Park Basel Area, Park INNOVAARE, Park Zurich, Park Network West EPFL and Park Biel/Bienne. At these locations, the infrastructure will be upgraded and resources will be pooled to create focal centres for industrial research and development.

The ETH Domain institutions' role was key for the ongoing establishment of "Switzerland Innovation" park. Members of the ETH Domain institutions and the ETH Board are strongly represented on the Foundation Board and on the Foundation Board Committee. The ETH Domain institutions have contributed in a productive manner to this project, respecting the distribution of responsibilities among the political authorities involved: ETH Zurich and Empa are participants at the Park Zurich located on the Dübendorf airfield site, EPFL has a leading role in the Park Network West EPFL – a network of six parks in Western Switzerland covering all innovation areas – and PSI plays a central role in the PARK INNOVAARE at Villigen in the Canton of Aargau.

A.2.3 Fostering the Creation of Successful Spin-offs

The ETH Domain institutions have set up various programmes to raise awareness among their faculty and employees of the socio-economic value of research results and to stimulate inventions and business ideas. Due to the novel nature and often very early stage of technologies resulting from fundamental research, the successful transfer of such technologies to existing industrial players has proven to be particularly challenging.

²² www.switzerland-innovation.com/

Therefore, spin-offs are well-established and very important vehicles for fostering innovation and transferring technology to industry, economy and society. Such spin-off companies²³ are founded and developed by scientific talents with an entrepreneurial mindset. In order to stimulate the creation of spin-offs and to support their entrepreneurs from the very beginning, the ETH Domain institutions offer a comprehensive set of instruments to identify, foster, promote and mature the entrepreneurial aptitudes of their students and collaborators. For further information, see Appendix A.2.

These instruments include

- stimulation programmes (e.g. the Spark Award for the best invention of the year at ETH Zurich);
- proof-of-concept and entrepreneurship support funding schemes (e.g. Innogrants and X-grants (student-based entrepreneurship)/Y-grants (social entrepreneurship), Enable programme at EPFL, Pioneer Fellowship at ETH Zurich, PSI Founder Fellowship Programme);
- dedicated office and lab space (e.g. Innovation & Entrepreneurship Labs (ieLabs) at ETH Zurich and Technopark, La Forge's incubator at EPFL Innovation Park, and the glaTec, Startfeld and the Thun start-up incubators at the Empa sites);
- community building (e.g. at ETH Zurich, through the ETH Entrepreneurship Club, the ETH Founders Community, Alumni Homecoming Dinners, and at EPFL through numerous networking events related to EPFL Innovation Park ecosystem, etc.);
- activities beyond the ETH Domain to foster entrepreneurship in general in Switzerland (e.g. Venture Businessplan Competition, engagement in the context of DigitalSwitzerland (e.g. kickstart accelerator), MassChallenge supported and located at EPFL Innovation Park);
- platforms and networks to facilitate access to risk capital (e.g. the SPIED, Spin-Off Information ETH Domain, website²⁴).

The impact of the spin-offs from the ETH Domain institutions can be measured on various levels.

- The economic impact study commissioned by the ETH Board estimated that all (659) spin-offs from institutions of the ETH Domain that were still active in 2016 generate an estimated CHF 1.6bn in turnover and employ 6,600 people in Switzerland (cf. Chapter E.1).
- Every year, many ETH Domain spin-offs are among the winners of the TOP Swiss start-ups ranking. In 2017 Lumigbo (now Lumendo) won the Business Plan Competition; Lumendo is a spin-off from both EPFL and ETH Zurich.
- At an early stage, spin-offs are frequently awarded prizes, feature in lists of the best start-up companies, and are portrayed in news media such as the NZZ, Red Herring, The European Wall Street Journal, CNN, etc. ETH Zurich and EPFL are both partners of the national business plan competition "Venture.ch".
- EPFL spin-offs have attracted prestigious US funds both in IT (TypeSafe, Kandou) and in Life Sciences (Anokion, Quartet, Mitokyne, Bicycle).
- The spin-offs are increasingly attracting the attention of big corporates as acquisition targets. In 2016 the ETH Zurich spin-off Autoform was acquired by Astorg Partners for US\$ 721m, and GlycoVaxyn (founded in 2004) for US\$ 190m. For 2017, examples include the 3D division from

²³ An ETH Domain spin-off is a company that is based on intellectual property generated in an ETH Domain institution and is founded by ETH Domain staff or students based on their activity in their institution. The company has to be based on a sound and sustainable business idea/business plan.

²⁴ <https://spied.ch>

Dacuda (acquired by Magicleap), the energy company Adaptricity (by LEONI) and the IBM Research and ETH Zurich spin-off SwissLitho (by Heidelberg Instruments).

- In 2017, 5 spin-offs from EPFL were acquired by companies. In particular, Globus Medical, a leading musculoskeletal solutions company, acquired KB Medical, which develops solutions for medical robotics. Parrot acquired Pix4D in order to further strengthen its drone-based business solutions after having already acquired SenseFly, another EPFL spin-off active in the field of drones, back in 2012. It is also worth mentioning that Mindmaze, an EPFL spin-off and subsequent unicorn which builds intuitive human-machine interfaces through its breakthrough neuro-inspired computing platform, acquired two other spin-offs from EPFL, namely Gait Up and Intentio. This phenomenon of acquisition within the EPFL's innovation ecosystem is indeed new.
- The acquisition of ETH Domain spin-offs may also be seen by non-European corporates as a means of entering the European market. For such companies, this additionally makes Switzerland an attractive landing spot for setting up a European head office.
- Not all the companies are acquired and, although they may grow slowly in some cases, they reach maturity over time. Nexthink is such an example: it has more than 200 employees 14 years after its foundation in 2004. In March 2018, an ETH Zurich spin-off Sensirion with more than 600 employees worldwide, went public at the SIX, 20 years after its incorporation.
- Whether acquired or independent, spin-offs from the ETH Domain usually keep Switzerland as their home base. This generates jobs and revenues, which in turn generate tax income as well. In some cases, this even results in a re-evaluation of their head office location – as in the case of GetYourGuide, which started in Zurich then moved to Berlin and is now coming back to its roots.
- The research institutes also have a proven track record of successfully created spin-off companies. For instance, the companies SwissNeutronics and Dectris have developed from initiatives at PSI into world market leaders in neutron optical devices and X-ray detectors.
- GratXray, a spin-off of PSI and ETH Zurich founded in 2017, focuses on a new method for the early diagnosis of breast cancer. It is developing a computer tomography system that is unique worldwide. This will be pain-free for patients in comparison with conventional mammography and, through highly precise three-dimensional imaging, will enable earlier diagnosis of breast cancer and reduce false diagnoses. The method was originally developed for tomographic imaging on the synchrotron source SLS. Within a period of two years, a prototype of a better mammography system is expected to be developed. GratXray received the 2017 Swiss Technology Award in the "Inventors" category, in which young Swiss start-ups as well as innovative business ideas with high market potential can qualify.
- Empa's business incubators nurture their own spin-offs and, in addition, numerous start-ups from outside that seek the vicinity of Empa's research labs in Dübendorf, St. Gallen and Thun. As an example, Swiss Wood Solutions, which was founded in 2017, has specialised in alternatives to tropical woods, e.g. for making musical instruments. Its 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. Another spin-off, Nahtlos (seamless), offers product development using an innovative technique developed at Empa that welds together synthetic fabrics and makes the "seam" both airtight and waterproof.
- Eawag, mainly active in the public goods sectors, recently also started to promote the creation of spin-offs. Up to now it has produced six spin-offs, one of which is a consultancy company.
- Widespread spin-off support at the ETH Domain institutions has steadily increased awareness among students of the economic value of their research and supported an entrepreneurial mindset.

In conclusion, the ETH Domain spin-offs have a noticeable impact on the Swiss economy and are an important vehicle for making novel technologies available to society.

A.2.4 Attracting Talents, especially Women

Attracting national and international talents at the student, doctoral and postdoctoral level

The research-based education offered by the ETH Domain is very attractive, as shown by the significant increase in student and doctoral student numbers over the last ten years: the student numbers were up by 54 % from 16,233 in 2008 to 25,055 in 2017 while the number of doctoral students increased by 29 % from 4,823 to 6,234 in the same period (cf. Figure 3 in Chapter A.1). The two schools' top positions in international rankings, the high living standards and the bright economic and professional prospects for graduates are also a factor in students' choice of ETH Zurich or EPFL for their education.

The proportion of international students and doctoral students is lower at the bachelor's level (29 % in 2017) than at the master's or doctoral levels (46 % and 75 % respectively in 2017). Some of the international students and doctoral students received their qualifying education in Switzerland. For details, see Figure 14 in Appendix A.2.

The master's courses offered by both Federal Institutes attract a large number of students with a bachelor's degree from another university every year. ETH Zurich and EPFL follow a careful process to choose those "external" applicants that best fit the master's curricula;

- In 2017 ETH Zurich received 3,586 and EPFL 2,631 applications for master's programmes from students with bachelor degrees from universities outside the ETH Domain (over 90 % of whom had bachelor degrees from universities abroad). 33 % of the external applicants were accepted at ETH Zurich and 24 % at EPFL. Of these, about 60 % and 46 % finally took up their master's studies at ETH Zurich and EPFL respectively.

A majority of the international students who obtained a master's degree or doctorate in the ETH Domain work in Switzerland after their graduation. Thus, not only are they educated in Switzerland but they also represent a substantial qualified workforce that contributes to the Swiss private and public sectors. Surveys of graduates indicate that:

- at ETH Zurich, one year after graduation, 71 % of all international graduates with a master's degree and 65 % with a doctorate are working in Switzerland; after five years the figures are 64 % and 67 % respectively (2015 survey of 2010 graduates).
- at EPFL, one year after graduation, 56 % of all international graduates with a master's degree and 60 % with a doctorate are working in Switzerland (graduates of 2016). The international master's graduates of 2011 were 72 % to work in Switzerland in June 2018, and the international doctorate graduates were 56 %. (cf. Appendix A.3 for more information on surveys of graduates).

The number of exchange students is another indication of the attractiveness of ETH Zurich and EPFL for international students. They study for one or two semesters at ETH Zurich or EPFL while remaining affiliated with their home university. In 2017 ETH Zurich and EPFL each received over 400 incoming international exchange students.

In order to attract the best talents at the student, doctoral and postdoc levels, ETH Zurich and EPFL have developed various measures. These include increasing visibility, adequate support throughout studies, funding opportunities and professional perspectives.

Both ETH Zurich and EPFL benefit from high visibility due to their good position in international rankings but also through targeted promotion and recruitment activities:

- There are eight well-established job fairs for ETH Zurich master's students and doctoral students per year. The student-run Polymesse, with over 140 participating companies,

is one of the largest recruitment events in Switzerland. In addition, a two-day workshop exclusively for doctoral students is offered twice a year by the ETH Career Center.

- The visibility of EPFL and its Doctoral School is growing due to targeted promotion activities (presence at job fairs, creation and distribution of the Doctoral School and programme brochures).

ETH Zurich and EPFL provide support to their students and doctoral students during their studies, as well as various funding opportunities.

- To assist students and researchers during their time at ETH Zurich, the university provides a wide range of support, adapted to the different stages of studies and career. The support ranges from personal consultations (e.g. in housing, child care, career counselling, funding opportunities) to legal assistance in patenting issues.
- ETH Zurich and EPFL offer a wide range of competitive funding instruments and awards, as well as prizes for outstanding achievements in teaching, research and technology transfer^{25,26}. These funding opportunities are adapted to the different career stage of a researcher. It should enable especially young investigators to be successful in the national and international science system. An example for master's students at ETH Zurich is the Excellence Scholarship & Opportunity Programme (ESOP), which supports them not only to cover their living costs, but also with a valuable network of other ESOP students at ETH Zurich. Similarly, EPFL offers a limited number of fellowships to master's students with outstanding academic records. Some of the fellowships are financed by EPFL directly and others through partnerships with foundations or companies. For doctoral students – most often funded directly by their supervising professors – funding opportunities are mainly intended to create networks and exchange possibilities.
- An important structure at EPFL supporting doctoral students in their career is the Doctoral School. Doctoral candidates are evaluated and admitted by decisions of the doctoral programme committee rather than individually by professors. The applicants are thus evaluated all together, which favours the selection of the very best candidates;
- The doctoral students actively participate in the management of the Doctoral School and doctoral programmes: they have representatives on the programme committees and there are dedicated meetings of the EPFL senior management with these representatives;
- A comprehensive doctoral supervision framework is in place with independent contacts and possibilities for support – mentor, programme director, doctoral student representative, deputy Vice President for the Doctoral School – thus helping to keep the doctoral students on board;
- EPFL strongly emphasises the importance of also acquiring transferable skills during doctoral studies – teaching, presentation, business, management, etc. Several initiatives to enhance the offering and attractiveness of transferable skills courses – PhD Excellence program, EPFLinnovators, collaboration with EuroTech and other universities – have been, or are being, launched.
- At ETH Zurich the doctoral programmes are organised as doctoral schools in the following fields. In life sciences and mathematics ETH Zurich and the University of Zurich jointly run the Life Science Zurich Graduate School and the Zurich Graduate School in Mathematics. In plant sciences University of Zurich, ETH Zurich and University of Basel jointly run the PhD Program in Plant Sciences.

²⁵ <https://www.ethz.ch/en/research/research-promotion/fellowship-programmes-specifically-for-young-researchers.html>

²⁶ <https://research-office.epfl.ch/page-103594-fr-html/page-98325-en-html/>

All the ETH Domain institutions provide career development support (especially for women) and employment perspectives both within and outside of academia:

- At ETH Zurich, the ETH Career Center offers valuable advice, a large spectrum of career services as well as dedicated programmes for female students, such as the Femtec Programme, to start a career outside university with a company²⁷.
- At the postdoctoral level there are many more funding instruments and programmes at ETH Zurich to promote the independence of highly talented researchers, e.g. the ETH Zurich Postdoctoral Fellowships, the ETH Zurich Career Seed Grants, or Society in Science – The Branco Weiss Fellowship²⁸.
- EPFL takes part of the “Réseau romand de mentoring pour femmes” for female doctoral students at the end of their doctorate and for female postdocs aiming at an academic career.
- During the semester, one networking lunch per month is organised on average at EPFL for enabling female students, doctoral students and postdocs to interact with role models from academia, industry, start-ups, etc.
- EPFL organises the REGARD Workshop Programme, which includes approx. 20 workshops per year on career development, transferable skills, etc. for female doctoral students, postdocs and faculty members (selected workshops, e.g. on academic mobility and dual career planning, are also open to men).
- All the institutions of the ETH Domain finance and run the programme Fix the Leaky Pipeline!²⁹, which offers coaching, training and mentoring for female doctoral students, postdocs and young scientists in the ETH Domain.
- ETH Zurich, EPFL, PSI and Empa participate to the EU Cofund Programs for postdocs. This programme has been very successful in attracting young talented scientists from abroad.

Attracting talents at professorship level, especially women

ETH Zurich and EPFL recruit all over the world in order to gain access to and employ the most talented professors. In 2017, international faculty members represented 67 % of the professors (assistant, associate and full professors). Women make up 15 % of the total. This is partly because the areas of activity in which ETH Zurich and EPFL have specialised (STEM) are those in which women are generally underrepresented worldwide. However, the proportion of women professors is constantly increasing, albeit gradually. In 2008, women represented 10 % of the professors, 14 % in 2016 and 15 % in 2017 (cf. Figure 15, Appendix A.2). This positive trend is a result of the numerous efforts that the ETH Domain institutions are making to improve gender balance among their members. They have implemented several measures, detailed below, to attract and retain talented women and thus further increase the proportion of women in faculty positions.

Recruitment of female faculty members

ETH Zurich

- Has adopted a gender strategy at professorship level.
- Advertises with gender-neutral or female-supporting vocabulary.
- Requests that the hiring department should indicate female role models and potential female candidates in the profile paper.

²⁷ <https://www.ethz.ch/en/the-eth-zurich/working-teaching-and-research/support-services-studies-careers.html>

²⁸ <https://www.ethz.ch/en/research/research-promotion/fellowship-programmes-specifically-for-young-researchers.html>

²⁹ <https://www.fix-the-leaky-pipeline.ch>

- Includes at least two external/internal female professors in each search committee.
- Has delegates reminding the search committee at the beginning of each search that ETH wishes to increase the number of female professors.
- Searches proactively for potential female candidates.
- Invites at least one potentially eligible female candidate for interviews.
- Creates additional positions to hire female professors with ETH Zurich funds.
- Has several departments which have committed themselves in their strategy to recruiting women and to thus actively search for female candidates for direct hires.

EPFL

- Has adopted a Policy for equal opportunities in faculty recruitment. The policy provides a framework to accentuate progress in recruitment of female faculty. The policy is based on the following principles: proactive search; awareness of implicit biases; quality of procedures; accountability.
- Provides training seminars to raise awareness of implicit gender biases in recruitment procedures. These seminars are compulsory for chairs of committees. Senior Management (Presidency; deans) has participated in the course, too.
- Requests that schools define specific aims and measures to encourage the recruitment of female professors within the framework of the EPFL gender action plan. The School of Architecture, Civil and Environmental Engineering runs a working group and the College of Management and Technology has put into place a visiting professors programme.
- Has internally put in place a (gender) monitoring of recruitment and promotion procedures. This also involves reports by search committees on the efforts deployed to attract a diverse and excellent pool of candidates and to prevent bias in the evaluation procedure.

Dual career support

- The comprehensive support and advice provided by the Dual Career Advice office (DCA) at ETH Zurich focus on all matters regarding professional and personal integration of new faculty members and their partner/family in Switzerland. An important aspect is to assist in exploring career opportunities for partners of international faculty members who are in the process of being recruited.
- In the case of dual scientific careers, ETH Zurich helps by contacting professors at ETH Zurich and outside who work in related fields and introduce the partner to the relevant community. Since (outside) funding might not be available at the very beginning, the President of ETH Zurich can co-finance a temporary position for a second hire for an initial period.
- ETH Zurich and EPFL provide support to new faculty members and their partner/family regarding dual career and integration (support for the professional integration of the second hire, privileged access to childcare and other care opportunities to balance professional and private life, etc.).
- EPFL is developing a spouse programme. Until implemented, EPFL continues to provide ad hoc targeted support according to candidates' needs.
- All the ETH Domain institutions participate in the international dual career network.

Career support and advancement at the faculty level

- ETH Zurich and EPFL ensure equal nomination of male and female faculty for prizes and awards.
- The women professors of the ETH Domain have created a private association (ETH Women Professors Forum) aiming to unite women professors within the ETH Domain and to serve as a sounding board for executive bodies in the area of promoting women in science. It creates platforms for exchange, support, networking and mentoring. The regular meetings also allow assistant professors to exchange with experienced full professors.
- Specific support is put in place for women professors with children. At ETH Zurich, this includes giving female professors financial assistance to hire a senior scientist during maternity leave. Both ETH Zurich and EPFL prolong the contract of an assistant professor for one year in the event of maternity.

Attracting and retaining talents at the ETH Domain research institutes, especially women

The visibility and reputation of the ETH Domain institutions are conducive to recruiting excellent and diverse talents from Switzerland and all over the world. Good working conditions, high living standards, personal and career support as well as equal opportunities are paramount to being attractive employers.

- PSI has put in place the Career Return Programme after a family break.
- The Eawag Directorate has introduced Tailwind Grants; these provide short-term support allowing mothers a rapid re-entry into scientific work after maternity leave.
- PSI has a mentoring programme for women with leadership ambitions at PSI.
- All the institutions support the Fix the Leaky Pipeline! Programme.
- WSL's Visiting Fellows Program, launched in 2015, allowed around twenty top scientists from all over the world to spend a research stay of several months at WSL. The presence of high-profile visiting fellows increases WSL's attractiveness for young talents.
- Empa's attractiveness for young talents as well as for outstanding scientists is based on:
 - a very dynamic research environment with a multicultural touch;
 - numerous international and interdisciplinary cooperations;
 - the benefits of a widespread network with partners from both industry and academia;
 - close collaboration with industry.
- Empa has won a number of awards for its family-friendly work environment and employment conditions and for its well-embedded culture of diversity and equal opportunity. In addition to the "Familie UND Beruf" (family AND career) award, classified as "best practice", and the Prix Balance ZH, an award for HR Excellence in Research was received from the European Commission Research and Innovation in 2017.
- Eawag has been the most successful ETH Domain institution in achieving diversity, particularly among its scientific staff and leadership. In 2017, women at Eawag accounted for 43 % of the directorate, 23 % of the research department heads (including the Eawag-EPFL Centre for Applied Ecotoxicology), 27 % of other tenured researchers and 43 % of tenure-track researchers. This success has been achieved through a portfolio of measures to support women in their scientific careers which began with the provision of on-site child-care nearly 25 years ago. Most recently, Eawag instituted a grant programme which helps mothers returning from maternity leave to set priorities for their work and delegate effectively. A list of all Eawag's measures to support diversity is available at <https://osf.io/rnjs4/>.

Gender Strategy 2017–2020: Strategy for Gender Balance and Equal Opportunities for Women and Men

In 2017 the ETH Board adopted its Gender Strategy for the period 2017–2020 with the objective of continuing to increase the proportion of women in the ETH Domain in the coming years. (cf. Appendix A.2)

It is the responsibility of the institutions to implement the gender strategy through appropriate measures adapted to their respective situation. The ETH Board takes note of these measures through the biennial reports and ensures that the corresponding financial resources are made available. It is also watching the development of the gender balance based on gender monitoring at ETH Zurich³⁰ and EPFL³¹.

³⁰ ETH Zurich Gender Monitoring 2017/2018 <https://www.ethz.ch/services/en/employment-and-work/working-environment/equal-opportunities/strategie-und-zahlen/gender-monitoring.html>

³¹ EPFL Gender Monitoring 2017–2018 https://equality.epfl.ch/files/content/sites/equality/files/GenderMonitoring/2018/GenderMonitoring_EPFL_en.pdf

Appendix A.2

Instruments and Activities to Encourage the Founding of Spin-offs

ETH Zurich

ETH Zurich seeks to foster the entrepreneurial spirit of its students from a very early stage and throughout their academic career. Various programmes and projects are implemented to this end:

- Since 2016 ETH Zurich has had a Professor for Entrepreneurship at the Department of Management, Technology and Economics (D-MTEC).
- Focus Projects have become a tradition for bachelor's students at ETH. Teams of students from various engineering and science backgrounds have to solve a technical problem or develop a prototype within one year. Many of these projects are the basis for successful spin-off companies, e.g. Wingtra.
- Every spring, the most promising invention of the previous year is awarded the Spark Award.
- The Student Project House (SPH) is a creative think- and makerspace open to all students at ETH Zurich. SPH started a pilot in 2017; Swissloop is a project that arose from SPH.
- Since 2010, when the Pioneer Fellowship programme was initiated and until the end of 2017, 47 new spin-offs were created based on the programme. The Pioneer Fellows receive CHF 150,000 for 12 or 18 months to further develop the technology, build up the business case, receive coaching and join networking events to prepare them for a potential spin-off incorporation. The Pioneer Fellows spend their time in the Innovation & Entrepreneurship Lab (ieLab). Two locations exist: one shared with the Entrepreneur club, and one for life science projects and spin-offs.
- Continuous entrepreneurial education is achieved by three measures:
 - In the weekly ieLab Lunch Seminar series, i) experienced professionals relate current problems and best business practices of all aspects of today's entrepreneurial life; ii) the Fellows are made aware of the many existing courses covering most aspects of entrepreneurship, offered for example by D-MTEC, Innosuisse, Technopark, VentureKick, VentureLeaders, Venturelab etc.; and iii) specialised training that cannot be found elsewhere is organised for the ieLab's young talents (e.g. negotiation skills, enhancement of legal knowledge, etc.).
 - The activities of the ieLab are effectively complemented by events such as:
 - regular networking and partnership events, including the ETH Industry Days;
 - the Meet-the-Pioneer evening and the yearly Spin-off Dinner open to all former ETH spin-off companies that have developed into successful ventures; access to powerful networks of national organisations supporting entrepreneurship (Venture Business Plan Competition, Innosuisse Start-up, Institut für Jungunternehmen, Venture Leaders, Venture Kick, US Entry Camp, etc.);
 - access to potent financing networks (SECA, ZKB, business angels and venture capital investors) as well as local incubator/business-park type Infrastructure (BlueLion, Technopark, BioTechnopark, etc.) complementing the entrepreneurship ecosystem.

ETH Zurich's efforts have led to a continuous flow of new spin-offs – 25 spin-off every year for the last three years – that frequently receive prestigious prizes. These rank among the most promising ventures in Switzerland, attract significant national and international investments and become either highly sought-after acquisition targets of big corporates or highly successful stand-alone Swiss companies.

EPFL

EPFL attaches great importance to fostering entrepreneurship and has developed a wide range of support initiatives and programmes serving this end:

- Students are encouraged to discover entrepreneurship through courses and conferences. The College of Management of Technology is responsible for the courses offered as electives at the bachelor's level, as well as for the Master's in Management of Technology and Entrepreneurship (MTE) and the Executive MBA dedicated to technology and innovation management.
- The Vice-Presidency for Innovation (VPI) co-organises the venture ideas cycle of conferences; twice a year high-tech entrepreneurs are invited to share their experience with the EPFL community.
- VPI also manages the Innogrants. Since 2005, grants of a maximum of CHF 100,000 have been awarded to about 120 out of more than 800 applications, thus helping in the creation of more than 78 spin-offs.
- VPI has launched two new entrepreneurship support programmes, namely the X-grants (to foster student-based entrepreneurship) and the Tech4Impact initiative (to promote entrepreneurship with a social impact).
- The Vice-Presidency for Research's TTO (Technology Transfer Office) further structures the licenses of technology to its spin-offs and continuously develops the Enable programme to accelerate proofs-of-concept for technologies. Master's students are invited as interns for the programme.
- VPI also recently renovated La Forge, a co-working open space area at EPFL Innovation Park for incubating venture ideas, where these new entrepreneurs can work on their projects, meet and learn from their peers and receive the support of this rich entrepreneurial ecosystem. At La Forge, bimonthly workshops are organised there between entrepreneurs, investors and service providers.
- VPI is a major sponsor of the Venture Leaders programme, which selects 20 promising young entrepreneurs to discover the Boston innovation ecosystem. VPI also organises entrepreneurship trips to San Francisco as well as entrepreneurship camps in London and Berlin in order to enable EPFL's entrepreneurs to discover other dynamic innovation ecosystems. Since 2014, EPFL has been awarded funding together with the other universities of the Eurotech consortium to build an equivalent European Venture Programme. This is part of the effort to expose entrepreneurs as early as possible to markets – and in particular to their international angle – through partnerships with the local Swissnex houses.
- In collaboration with the EPFL Innovation Park, VPI further supports the 15–25 spin-offs created each year by helping them in their development through multiple support tools such as the Fondation pour l'Innovation technologique, Prix Vittoz and other entrepreneurial prizes.

Research Institutes

PSI encourages its scientists to exploit inventions, which may develop into spin-off companies:

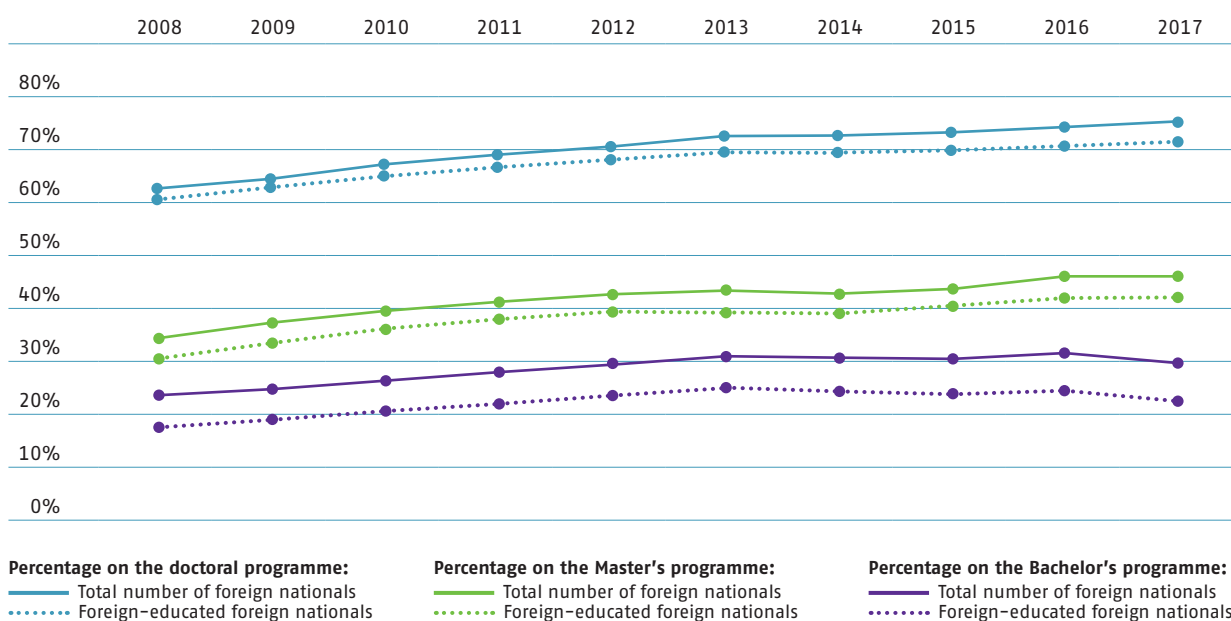
- Since 2017, PSI has launched a yearly call for the PSI Founder Fellowship programme. The goal of the fellowship is to support proof of concept projects, thereby bridging the pre-foundation period between the generation of a business idea born from scientific research or engineering at PSI, and the start of a spin-off company. The fellowships are competitive grants up to CHF 150,000 and provide funding up to a maximum of 18 months for a single fellow. One of the three winners of the first PSI Founder Fellowship call, the spin-off Araris (in formation) using a technology invented at PSI to develop cancer drugs more quickly and reliably than before, was among the finalists for the Swiss Technology Award 2017.

Empa fosters about two to three new spin-offs each year through its two business incubators: Dübendorf, and the St. Gallen-based tebo, which is part of the Startfeld innovation and start-up network in the St.Gallen/Bodensee area. The majority of these spin-offs enjoy above-average success – as attested by the various prizes they win, the financing they are able to secure, and the industry collaboration they achieve.

- The Empa spin-off MIRO Analytical Technologies founded in 2018 developed a technology to simultaneously analyse nine greenhouse gases and pollutants with only one device and with unprecedented speed and precision.
- In 2018, the Empa spin-off CTsystems, and Daetwyler, the Swiss specialist for sealing solutions, partnered up to market and industrialise polymer transducer technology.
- Startfeld extended its space significantly from 900 m² to 4,300 m² in November 2018 to support both ambitious entrepreneurs and established SMEs. In the context of strengthening its Thun research location, a startup incubator is being set up at Thun.

International students and doctoral students³²

Figure 14: Foreign nationals as a percentage of students and doctoral students³²

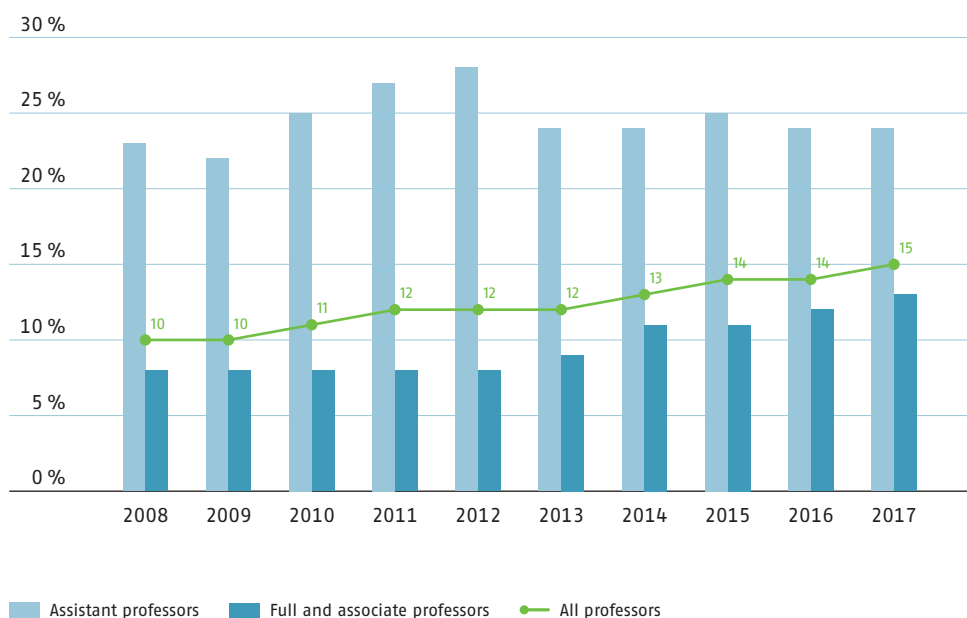


Foreign students and doctoral students form two sub-categories: foreign-educated students of foreign nationality who were resident abroad while obtaining the relevant necessary qualifications, and Swiss educated students of foreign nationality who were resident in Switzerland while obtaining the relevant necessary qualifications.

³² Annual Report of the ETH Board on the ETH Domain 2017

Women professors

Figure 15: Proportion of women professors



Women are generally underrepresented in STEM domains, in particular at professor level. ETH Zurich and EPFL have developed multiple measures to counteract this phenomenon, leading to a slow but steady increase in the proportion of women professors. "All professors" include assistant professors with and without tenure track, associate professors and full professors. Adjunct professors are not included. The proportion of women professors is calculated based on full time equivalents (FTE).

Gender Strategy 2017–2020: Strategy for Gender Balance and Equal Opportunities for Women and Men

The ETH Domain aims to improve the gender balance among its members by increasing the share of women in education and in research, as well as in management positions. Ensuring equal opportunities for women and men within the ETH Domain is a prerequisite for achieving this objective.

This Gender Strategy 2017–2020 outlines an overarching strategy to foster gender balance and equal opportunities for women and men within the ETH Domain. While the broader concept of diversity is important to the ETH Domain as well, this strategy focuses on the gender dimension only in order to adopt an efficient and targeted approach. It includes general principles and consists of five focus areas. Measures required for achieving the objectives laid down here may differ from one institution to another. Therefore, the individual ETH Domain institutions are responsible for implementing the present strategy through adequate actions that match their respective situation.

Improving gender balance and equal opportunities for women and men requires incorporating as much knowledge as possible regarding the effectiveness, the impact and the secondary effects of potential measures. The ETH Domain institutions collaborate in the assessment of measures practiced within the ETH Domain, in Switzerland or in other countries, particularly within universities and research institutes but also within partner companies. The institutions also consider relevant insights from scientific literature and recommendations in order to identify measures with high potential to support the ETH Domain in reaching its goals. The

Domain's Working Group on "Equal Opportunities" facilitates the exchange and fosters collaboration between the ETH Domain institutions, while the ETH Board meets its role as a strategic management and supervisory body by monitoring gender balance and equal opportunities for women and men throughout the ETH Domain.

The present strategy concerns all members of the ETH Domain, women and men, including students, employees in technical or administrative positions, and employees in scientific or management positions.

Focus Area 1: Strong anchorage of equal opportunities in the institutions

A strong institutional anchorage and commitment of the top management level is a central factor for the implementation and effectiveness of gender balance and equal opportunity policies. The responsibility for implementing such policies lies with the Presidents or Directors and the Executive Boards of the respective institutions and with the heads of their sub-entities (e.g. faculties, departments, administration) according to the institutions' individual structure. The development and implementation of equal opportunity policies in the ETH Domain institutions is supported by professional structures, as well as by staff linked to the Presidents or Directors, respectively.

Implementing a strategy on gender balance and equal opportunities for women and men requires goals, implementation measures and monitoring instruments. All ETH Domain institutions formulate their own specific Gender Action Plans (GAPs) based on the focus areas outlined in the present strategy.

An appropriate financial commitment is essential for strengthening existing efforts or launching new instruments on the level of the individual institutions. Therefore, the Strategic Planning of the ETH Board for the ETH Domain for the period of 2017–2020 stipulates that the member institutions will continue to spend at least 0.4 % of the annual Federal financial contribution for implementing measures supporting the promotion of equal opportunities. The financial resources should be used to foster gender balance and equal opportunities for women and men in a broad sense. The respective measures should be diverse and well balanced. Supporting childcare facilities should only account for a small proportion of these measures.

Focus Area 2: Awareness of gender stereotypes and biases, respectful conduct and communication

Gender stereotypes are an impediment to gender balance and equal opportunities. All ETH Domain institutions take action to enhance awareness among their members regarding stereotypes and their impacts. They implement measures to systematically identify these stereotypes.

These measures may include workshops, lectures, online tools, etc. The ETH Domain institutions are also committed to detecting internal structural gender biases. Also, they ensure equal treatment regarding salary conditions and access to resources. All institutions implement a code of conduct, emphasising mutual respect and absence of discrimination, bullying, mobbing, threats, violence and sexual harassment, as key elements. The institutions train their members to comply with these principles and take measures against inappropriate behaviour.

Finally, the institutions of the ETH Domain integrate gender balance and equal opportunities for women and men into their various communication activities. They specifically endeavour to ensure an appropriate representation of women and men at public events and in representative situations. The institutions of the ETH Domain communicate in gender-impartial language.

Information on the institutions' equal opportunities strategy, action plans and measures is easily accessible and is part of the information packages for employees and students.

Focus Area 3: Career development for women at all stages

Based on monitoring and benchmarking, each institution defines indicative targets and specific measures for the advancement of women's careers in academia, administration and technical professions.

ETH Zurich and EPFL take appropriate measures to ensure that more women enrol in their bachelor's and master's programmes in fields of current underrepresentation. To this end, they also cooperate with secondary and teacher training institutions and other stakeholders active in the promotion of science outreach and education. They actively support female and male students throughout their studies in order to ensure equal chances for success.

The ETH Domain institutions take measures to attract the most talented female and male students and researchers, and to allow them to strive and excel on an equal footing. They develop strategies to increase the share of women at doctoral and postdoc levels and take specific action to foster female academic leadership. The institutions support measures such as mentoring, training and coaching intended to guide students towards academic, industrial and entrepreneurial careers.

Achieving a significant increase in the number of female professors and senior scientists, and improving career perspectives for women requires actions by all institutions, faculties or departments. As a basic standard, these actions should include the proactive search for female candidates, training for the hiring committee members to mitigate unconscious biases at all levels within the institutions, and proactive efforts to retain female faculty.

The ETH Domain institutions and the ETH Board strive for an appropriate gender balance for management positions (lower, middle and upper management), decision-making bodies at various levels (such as committees for research, strategy, hiring or tenure track evaluation), as well as in highly segregated sectors of the technical and administrative staff, including apprentices. The institutions regularly assess the gender balance in recruitment and promotion procedures, as well as in access to, and take-up of, staff development measures.

The institutions of the ETH Domain also address dual career issues and implement adequate measures to reconcile an academic career and family-related tasks which are relevant to the career promotion of women and men. Similarly, instruments for compensation for maternity leave or family-related absences are in place (such as a "stop the clock scheme" for tenure track positions or contract prolongation opportunities for doctoral and postdoc researchers).

Focus Area 4: Conditions for a good life domain balance

The institutions of the ETH Domain and the ETH Board provide work conditions supporting a good "life domain balance", which represents a more encompassing concept in comparison with the notion of work-life balance. The balance should be conducive to equal opportunities for women and men.

Day nurseries and childcare facilities for specific occasions (like emergency childcare, holiday activities, or childcare solutions for conferences) are further developed, based on the assessment of employees' and students' needs. Similar process applies for developing framework conditions to support care of the elderly, or enhanced care requirements of family members.

Solutions for work flexibility are promoted for women and men. Professors and leaders are alerted to the relevance of work flexibility and family-friendliness in achieving excellence in their respective institutions. Support and incentives to ensure the compatibility of work flexibilities of the ETH Domain provide employees and students with information and counselling so that they are aware of the wide availability of family-friendly work and study conditions.

Focus Area 5: Gender issues in research and teaching

The ETH Domain institutions take measures to ensure that gender-related aspects are taken into account in research projects, large research programmes and in (institutional) evaluations. They engage to train people involved in teaching, assessment and curriculum development to be aware of potential gender differences in learning strategies and perceived self-efficacy, as well as of their impact on examination methods. The measures adopted ideally build on research, innovative approaches and best-practice examples.

A.3

Coordination of Areas of Activity

Excerpt from the Mandate:

"Are the current areas of activity appropriate in the context of the coordination of the entire Swiss higher education sector and in meeting the needs of the economy and society? To what extent would it make sense to focus certain activities? The questions in this field are as follows:

- Are there areas in which overlaps exist with other higher education institutions or research institutes and where, from a national perspective and from the viewpoints of efficiency and efficacy, it would make sense to share tasks, or leave certain tasks entirely to another institution? Are there processes in place that allow the institutions and the ETH Board the identification of such areas?
- Is it possible to identify selective fields within the ETH Domain which contribute only indirectly to the fulfilment of the basic mandate, and which could if necessary be dispensed with, so as to free up resources for new fields of activity or others of higher strategic value? Are there processes in place that allow the institutions and the ETH Board the identification of such areas?"

A.3 Coordination of Areas of Activity

Assessment by the ETH Board

Assets

The two Federal Institutes of Technology and the four research institutes of the ETH Domain coordinate their research activities, contribute to the coordination of the Swiss higher education sector and share tasks in cost-intensive areas according to Art. 3 ETH Act³³.

The ETH Board shares the view that top-down initiated coordination efforts should be limited to specific cost-intensive areas; for all other areas of activity the bottom-up character of international and national cooperation and competitiveness are important success factors in view of the overall performance of the sector. In the view of the ETH Board the institutions are successfully using coordination in various areas of activity to yield powerful internal synergies.

- While ETH Zurich and EPFL are engaged in teaching based on world-class (and mostly fundamental) research, as well as in intensive knowledge and technology transfer activities, the four research institutes specialise in world-class fundamental research, in applied research in their focal areas and in technology development.
- Both ETH Zurich and EPFL have the “critical mass” of internationally renowned professors, senior scientists and MER (maîtres d’enseignement et de recherche) in each scientific field in which they offer research-based education. This ensures the highest standards of teaching and supervision, and attracts increasing numbers of students. Moreover, there are various examples of successful collaboration and coordination in teaching within and outside the ETH Domain; including the appointment of scientific staff at the four research institutes as adjunct professors at ETH Zurich and EPFL.
- In selected disciplines and areas of activity, the entire value chain – from basic research and teaching to the application of new knowledge – has to be covered in order to achieve a sustainable impact for society and economy.
- The renewal and re-orientation of professorships at ETH Zurich and EPFL and of leading positions at the research institutes is a continuous process that makes it possible to redirect research areas and move into new, promising areas.
- In terms of research and large-scale research infrastructures, the processes and instruments for coordination within the ETH Domain and on the national level (e.g. NCCR, SCCER, Swiss Roadmap for Research Infrastructures) are in place and are being developed further to ensure their efficacy and efficiency.
- The complementarity of ETH Zurich and EPFL with the universities of applied sciences – i.e. their distinct profiles – is a key success factor in the Swiss higher education system and is politically desirable.

“Are the current areas of activity appropriate in the context of the coordination of the entire Swiss higher education sector and in meeting the needs of the economy and society? To what extent would it make sense to focus certain activities? The questions in this field are as follows:

- Are there areas in which overlaps exist with other higher education institutions or research institutes and where, from a national perspective and from the viewpoints of efficiency and efficacy, it would make sense to share tasks, or leave certain tasks entirely to another institution? Are there processes in place that allow the institutions and the ETH Board the identification of such areas?
- Is it possible to identify selective fields within the ETH Domain which contribute only indirectly to the fulfilment of the basic mandate, and which could if necessary be dispensed with, so as to free up resources for new fields of activity or others of higher strategic value? Are there processes in place that allow the institutions and the ETH Board the identification of such areas?”

³³ Federal Act on the Federal Institutes of Technology, of 4 October 1991 (as at 1 May 2017)

Challenges

- Regarding national coordination of scientific activities keeping the balance between an international orientation and the related global competition on one side and maintaining a national perspective (incl. fulfilling national tasks) on the other side can be demanding for the institutions of the ETH Domain.
- Given the limited availability of resources (both human and financial), the ETH Domain institutions must be enabled – by virtue of their autonomy – to engage in a continuous portfolio development and to set posteriorities (e.g. to outsource routine procedures that no longer constitute forefront research topics, or to hand over such activities to private actors, including spin-offs) without political interference.

A.3.1 Areas of Activity

The ETH Domain's basic mandate of teaching, research, and knowledge and technology transfer is focused on exact, natural and engineering sciences with links to social sciences and humanities. In certain fields of engineering, education at university level in Switzerland is exclusively provided by ETH Zurich and EPFL (cf. Chapter A.1.1). As scientific breakthroughs often occur at the interface of disciplines, a certain variety of disciplines and areas of activity along the border of exact sciences with other disciplines need to be covered as well within the ETH Domain.

In the selected disciplines and areas of activity, the entire value chain from basic research and teaching to applications of new knowledge is covered to achieve a sustainable impact for society and economy. This can be achieved by the complementary character of the ETH Domain institutions and their areas of activity yielding powerful internal synergies. While ETH Zurich and EPFL are engaged in teaching based on the world-class (and mostly fundamental) research they perform, as well as in intense knowledge and technology transfer activities, the four research institutes specialise in world-class fundamental research and more applied research in their focal areas, and in technology development.

A.3.2 Teaching

ETH Zurich and EPFL attach great importance to offering curricula and study programmes that serve the prime mission assigned to them since their foundation: to train highly qualified experts in the fields of exact, natural and engineering sciences and to ensure that they acquire the relevant skills to take up leading positions in the private and public sector. Recent surveys among graduates from ETH Zurich and EPFL confirm that this objective is met to a very high degree (cf. Appendix A.3).

The curricula offered by ETH Zurich and EPFL generally both cover the disciplines of exact, natural and engineering sciences in order to provide research-based education in the different linguistic and cultural regions of Switzerland. At the bachelor's level, the majority of courses are taught in German at ETH Zurich and in French at EPFL. Thus both the Institutes of Technology foster the Swiss national languages and the cultural values as prescribed by the ETH Act³⁴. At the master's and doctoral level the courses are, with few exceptions, taught in English both at ETH Zurich and EPFL, thus attracting national and international talents. Most of the bachelor's graduates of ETH Zurich (95 %) and EPFL (84 %) choose to continue with their master's courses at ETH Zurich and EPFL, where they have the opportunity to study in stimulating international

³⁴ Federal Act on the Federal Institutes of Technology, of 4 October 1991 (as at 1 May 2017)

environments. Both ETH Zurich and EPFL have the “critical mass” of internationally renowned professors, senior scientists and MER (maîtres d’enseignement et de recherche) in each scientific field in which they offer research-based education. This ensures the highest standards of education and supervision and attracts increasing numbers of students.

There are various **processes** in place at ETH Zurich and EPFL to continuously evaluate the adequacy of study programmes and courses (cf. Appendix A.3).

- Development and evaluation of curricula
- Stakeholder involvement
- Graduate surveys and surveys on the employability of graduates

The principle of complementarity with actors in the higher education area is respected; the ETH Domain institutions retain study programmes that are primarily based on their fundamental and interdisciplinary research fields. Thus, their profiles remain clearly distinct from the teaching and research profiles offered by universities of applied sciences. In the long run, this serves – and therefore strengthens – the distinct profiles of each of the higher education institutions in Switzerland in agreement with the Higher Education Act (HEdA)³⁵. At the same time attention is given to permeability and mobility between higher education institutions.

Teaching collaboration and coordination outside the ETH Domain

There are various examples of successful collaboration and coordination in teaching outside the ETH Domain, including:

- the entire educational offering of ETH Zurich is open to students from the University of Zurich (UZH) and vice versa (credit points being fully recognised mutually);
- the educational offering in Life Sciences of ETH Zurich and the University of Basel (UniBas) are open to students from both universities;
- three joint master’s programmes ETH Zurich/UZH and one joint master’s programme ETH Zurich/UZH/UniBas;
- the new ETH Zurich Bachelor in Human Medicine in close cooperation with UZH, UniBas, and Università della Svizzera italiana (USI);
- several study programmes of ETH Zurich offered in close cooperation with UZH (e.g. Biology);
- joint doctoral programmes ETH Zurich/UZH: Life Science Graduate School (incl. UniBas), Zurich Graduate School in Mathematics;
- joint master’s programme in Applied Geophysics (ETH Zurich, Delft University of Technology and RWTH Aachen University);
- joint master’s programme in High Energy Physics (ETH Zurich and Ecole Polytechnique Paris);
- master’s programme in Teaching Methodology in Natural Sciences (Fachdidaktik Naturwissenschaften) (ETH Zurich, Zurich University of Teacher Education and UZH);
- courses offered by EPFL in mathematics and natural sciences or within the “Science au carré” programme for students at the University of Lausanne;
- courses in social sciences and humanities are taught to EPFL students by lecturers from the University of Lausanne;

³⁵ Federal Act of Funding and Coordination of the Higher Education Sector (HEdA), of 30 September 2011 (as at 1 January 2018)

- the EPFL sites Fribourg, Geneva, Neuchâtel and Valais-Wallis provide new opportunities for collaboration in teaching with universities of applied sciences and other academic partner institutions;
- numerous scientists of ETH Domain institutions teach at other higher education and research institutions³⁶;
- joint master's programmes (leading to joint master's degrees) as well as programmes in the field of continuing education have been developed and established together with partner universities;
- collaboration with medical schools and (university) hospitals has been significantly increased.
 - For the Human Medicine Bachelor at ETH Zurich the following partner hospitals are key: City of Zurich care homes (Pflegezentren der Stadt Zürich), cantonal hospitals in Aarau, Baden and Winterthur, Schulthess Clinic Zurich, University Hospital Basel, University Hospital Zurich, and several hospitals in Ticino. In addition, for the four-week long care internship, students can choose from almost 60 partner hospitals.
 - In the Life Sciences Engineering Bachelor's at EPFL, a one-year gateway ("passerelle") programme to the Master's in Medicine programme at the Universities of Lausanne and Geneva has been set up in close collaboration with these universities. Specific courses have been introduced and coordinated in the EPFL curriculum to prepare students for the "passerelle" (cf. Chapter A.1.1).
- The Architekturrat der Schweiz/Conseil suisse de l'architecture³⁷ is a discussion platform for architectural training in Switzerland. It brings together the various Swiss universities (including universities of applied sciences) that teach architecture. ETH Zurich and EPFL are members of the council, which aims to harmonise architectural training in Switzerland, promote research and, as a common platform, sensitise the political environment for architecture as a discipline.

Teaching collaboration and coordination within the ETH Domain

There are various examples of successful collaboration and coordination in teaching within the ETH Domain:

The interdisciplinary network of competencies of the ETH Domain institutions is a key success factor in teaching and provides excellent opportunities for students and doctoral students. In addition to the examples presented here, please see Chapter A.1.

- Master's in Nuclear Engineering, jointly taught by ETH Zurich, EPFL and PSI;
- New Master's programmes in Data Sciences at ETH Zurich and at EPFL;
- A new major in Cyber Security within the Master of Informatics programme from 2019 onwards – ETH Zurich and EPFL in parallel, with possible exchange semesters;
- The majority of doctoral students supervised by the research institutes are enrolled at ETH Zurich or EPFL (2017: 68 %);
- Exchange and mobility of students between the ETH Domain institutions is strongly encouraged and was supported financially by the ETH Board before the schools took over financial support in 2018. In 2017, 93 students took advantage of this programme by spending a semester in a different linguistic region, and 151 students participated in summer schools.

³⁶ Over 1/3 of the teaching hours of staff of the research institutes (i.e. 6,500 hours of the total 18,000 hours in 2017) were taught at institutions outside the ETH Domain.

³⁷ <http://www.architekturrat.ch/en/wer-wir-sind/>

In general, study programmes are periodically assessed and revised to meet the needs of society and industry and to include new developments in the respective fields. While the procedures are described in Appendix A.3 (Development and evaluation of curricula), the following examples illustrate the importance of renewal and reorientation in the study programmes.

- The study programme of mechanical engineering underwent a fundamental revision and is now the most sought-after study programme at ETH Zurich. It offers students a broad introduction to engineering, with world-class specialisations such as robotics.
- The “Agrofutur” revision of the programme of agricultural sciences.
- EPFL has embarked on a major curriculum reform to introduce computational thinking as a foundation course across science and engineering disciplines, as well as the development of disciplinary-specific computational thinking content in courses across different programmes.
- At EPFL the Master’s in Mathematics for Education has been transformed into a specialisation in the traditional mathematics master’s.
- At the EPFL Life Sciences School, two master’s programmes (Master’s in Bioengineering and Master’s in Life Sciences and Technology) were jointly integrated into a single master’s programme (Master’s in Life Sciences Engineering).
- The EPFL minor in computer engineering was discontinued in favour of more specific minors like the one in cybersecurity.

A.3.3 Research (incl. Research Infrastructures)

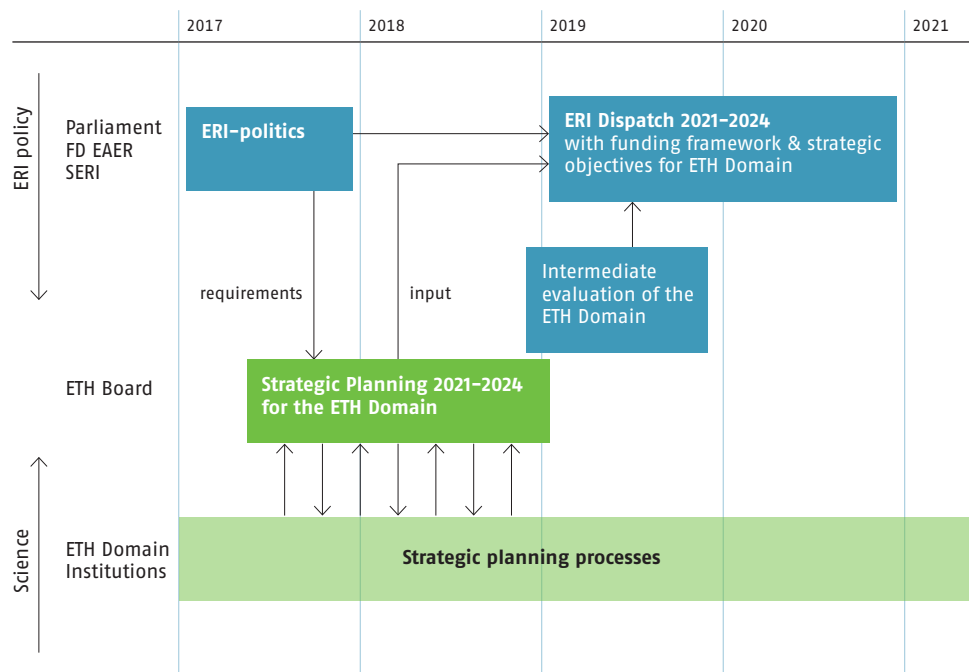
As ground-breaking discoveries which lead to innovation are difficult to project and predict, it is vital for all ETH Domain institutions to allow their researchers to freely define their research areas. Programme-oriented research, representing a top-down approach to setting research priorities, can be a reasonable means to push forward particular areas in which an urgent need for new solutions exists. Such top-down approaches can impair innovation if they absorb resources that would otherwise enable curiosity-driven fundamental research, which remains the key driver for ground-breaking innovation in the long term. Therefore, it is important to favour curiosity-driven research over top-down programme-oriented research. While the proportions may differ between the institutions, the goal of maintaining leading international positions in research and advancing science for the benefit of society and economy is the same. To make best use of the complementary character of the ETH Domain institutions and their areas of specialisation, there are processes in place to bundle competencies and resources.

The main **processes** of coordination related to research and research infrastructures include

- The Strategic Planning of the ETH Board for the ETH Domain;
- The Strategic Planning of the ETH Domain institutions;
- The renewal of professorships at ETH Zurich and EPFL and unit/group/laboratory heads at research institutes;
- The Swiss Roadmap for Research Infrastructures (cf. Chapter A.1).

The Strategic Planning of the ETH Board for the ETH Domain is the main instrument for proposing strategic initiatives and crucial aspects of science policy to be included in the ERI Dispatch (cf. Figure 16). This planning process is embedded in a dialogue: the ETH Domain institutions contribute the scientific content to the process (bottom-up), whereas the ETH Board defines top-down strategic key aspects related to governance and science politics.

Figure 16: Strategic Planning 2021–2024 of the ETH Board for the ETH Domain in the Education, Research and Innovation policy context



ERI: Education, Research and Innovation

FD EAER: Federal Department of Economic Affairs, Education and Research

SERI: State Secretariat for Education, Research and Innovation

The ETH Board formulates its strategy and sets priorities and strategic guidelines for the long-term development of the institutions especially:

- in areas where the demands and needs of Swiss society and industry need a specific additional effort for the common good;
- in areas where the framework conditions for the ETH Domain institutions' international and national success should be improved;
- in domain-wide strategic initiatives (strategic focus areas and research infrastructures) where coordination and/or financial requirements exceed the capacity of a single institution.

The bottom-up approach for strategic initiatives is an efficient coordination procedure within the ETH Domain and beyond. The ETH Domain institutions propose strategic focus areas and research infrastructures (new or major upgrades of existing infrastructures) based on their research competencies and priorities. The proposed strategic initiatives undergo a stepwise review and evaluation process before the ETH Board decides about their inclusion in the Strategic Planning. In the case of research infrastructures, the process is guided by the Swiss Roadmap for Research Infrastructures and includes a scientific evaluation by the Swiss National Science Foundation (SNSF) and an evaluation of implementation and funding by the ETH Board³⁸. The roadmap process ensures coordination among all actors in the Swiss higher education system. For further information about the ETH Domain's research infrastructures, see Chapter A.1.2.

³⁸ <https://www.sbf.admin.ch/sbf/en/home/research-and-innovation/research-and-innovation-in-switzerland/swiss-roadmap-for-research-infrastructures.html>

At the national level we refer to the key role of the SNSF in terms of coordination in specific research areas through National Research Programmes (NRP), National Centres of Competence in Research (NCCRs) and further funding schemes.

The **renewal** of professorships at ETH Zurich and EPFL and of unit/group/laboratory heads at the research institutes is a continuous process allowing redirection of research areas and shifts into new areas.

ETH Zurich

The planning of professorships forms a key organisation axis within ETH Zurich, ultimately determining the development of department's basic funding and accommodation requirements and the establishment of scientific platforms and infrastructure. The planning of professorships is thus firmly integrated in the Executive Board's business management process.

Every year, approx. 25–30 professors are appointed to replace retired professors. Each of these professorships is strategically reoriented according to the requirements of research and teaching and – where this makes sense – in coordination with expertise already in place or planned at partner institutions. In addition, about 15–20 new professors are appointed every year. Thus, every year, approx. 7 % of the university's range of competencies is reoriented. This is evidence of ETH Zurich's dynamic capacity for constant renewal in teaching and research, which not only sustainably promotes young academics and ventures into new expert fields that are relevant to the economy and society but also reinforces the central basic sciences.

The identification of new scientific fields constitutes a great challenge for every university. It is for this reason that ETH Zurich launched the strategic initiative ETH+ in autumn 2017. This initiative is intended to help identify new topics at the interface of disciplines and departments and to extend ETH Zurich's intellectual capacity in research, teaching and the transfer of knowledge and technology.

EPFL

EPFL pioneered the introduction of the tenure-track assistant professor model and continues to use it for a significant number of professorship hires. Particular attention is paid to candidacies combining scientific excellence with novel approaches to interdisciplinary research. Hires at the interface between different EPFL schools are encouraged. Research groups remain open and hierarchically flat, ensuring direct access to professors for students, doctoral students, researchers and society as a whole. The practice of Open Science is strongly encouraged.

Where advantageous, joint professorships with other institutions of the ETH Domain are initiated. As an example, the renewal of professorships in the broad area of energy is causing the institution's portfolio to evolve from dam or turbine design towards grid management, solar energy harvesting, energy storage (in cooperation with PSI) or addressing climate change. Other examples include: professorships in building engineering, indoor environmental quality, construction and sustainable architecture at EPFL Fribourg; and professorships in Changing Alpine and Polar Environments at EPFL Valais-Wallis.

The integration of future hires into the curricula of the relevant study branches is a prime concern during the recruitment process. Innovative teaching methods are encouraged where possible.

PSI

In the context of appointments or the commissioning of new large-scale research facilities and thus the opening up of new research fields or institutional restructuring, the focus and structure of the divisions/laboratories are evaluated. Topics or research fields due for discontinuation are identified and resources that become available are shifted to new topic areas.

Through joint appointments with the two ETH or universities, close links and alignment with the research priorities of the other institutions are established (creation of synergies, avoidance of duplication).

Recent examples include:

- establishment of new laboratories: femtochemistry, non-linear optics, applied photonics, nanoscale biology, multiscale materials experiments, scientific computing and modelling, environmental chemistry;
- laboratories closed: solar technology, combustion research.

WSL

Since 2017 the appointment of two new research unit leaders has led to strategic repositioning and the creation of the new units: 1) “Forest Resources and Management” is adopting a more scientific and international focus along with a thematic shift towards sustainable forestry for ecosystem services in the Forest Production Systems group, which is part of the research unit; 2) the creation of an additional research unit, Forest Health and Biotic Interactions. Like the construction of the Plant Protection Laboratory, grouping together and strengthening WSL’s capacity in phytopathology is part of a strategic decision made by the Directorate to position WSL as an international key player in this emerging research field.

Empa

Empa’s overarching strategic research topics are defined in five Research Focus Areas (RFAs: Nanostructured Materials, Sustainable Built Environment, Health & Performance, Natural Resources & Pollutants, Energy). The research laboratories define their two to four main areas of activity in these RFAs within the framework of four-year work plans. Typically, at least one of these activities is new while the others are a continuation of existing research. Thus, Empa’s 30+ laboratories continue to develop organically and to shift their focus if need be. One example is the transformation of the Advanced Materials Processing laboratory from coating technology to Additive Manufacturing (AM). The achievement of objectives is reviewed annually, and objectives for the subsequent year are adjusted if necessary. When filling key positions such as head of laboratory or group leader, Empa takes the opportunity to expand the institute’s range of competencies in new and attractive research areas. A typical example is the appointment of the head of the Applied Wood Materials lab for the further development of functional wood- and cellulose-based materials such as paper-based electronics.

Eawag

Within the general scope of its research on water resources, Eawag uses staffing decisions as a key mechanism to drive future research directions. Searches for tenure-track (or tenured) researchers are initiated following critical discussions between the directorate and heads of the research departments on needs and opportunities for maintaining existing capacities or moving in new directions. As an example, in the last three years hiring priorities have been shifted to exploit new opportunities in the acquisition, management and interpretation of high-resolution data and in the application of data sciences to water research. This in-house competency allows Eawag to take full advantage of the capabilities of the Swiss Data Science Center (cf. Chapter C.1.2). The appointment of joint professors is particularly important for Eawag, both as a point of contact with the ETH Zurich and EPFL (as well as with the cantonal universities and universities of applied sciences) and in strengthening Eawag’s capacities as a research institution.

There are various examples of successful collaboration and coordination in research and research infrastructures **outside the ETH Domain:**

Some initiatives within the ETH Domain are intimately linked to national initiatives relating to other parts of the Swiss academic system. One is the coupling of the Swiss Personalized Health Network with the ETH Domain’s SFA PHRT (cf. Chapter C.1.1).

Yet another mechanism for cooperation between the ETH Domain and cantonal universities are the National Centres of Competence in Research (NCCRs) co-financed by the SNSF. In many of these, units of the ETH Domain institutions are either cooperative partners or leaders of the NCCR.

Beyond Switzerland, the ETH Domain institutions are active partners in a number of formal international cooperation frameworks. An example is high-performance computing, where EPFL is the housing institution of CECAM (Centre Européen de Calcul Atomique et Moléculaire). In this European network for atomic and molecular ab-initio simulation, the CSCS is one of five members constituting the PRACE partnership for advanced computing in Europe.

Under the Action Plan on “Coordinated Energy Research Switzerland”, seven priority topics in energy research – establishment of eight Swiss Competence Centers for Energy Research (SCCERs) in total – were defined and are funded by Innosuisse. The role of the leading houses includes coordination of the research activities on the national level between all Swiss stakeholders in energy research (ETH Domain, cantonal universities, universities of applied sciences (cf. Chapter C.1.4).

WSL: National Plant Protection Laboratory

WSL operates Switzerland’s first and only safety-level-3 laboratory and greenhouse, the National Plant Protection Laboratory. This laboratory facilitates diagnosis and research into plant pests and diseases, the propagation of which can cause serious environmental and forestry damage. These tasks are being discharged under the aegis of the Swiss Federal Plant Protection Service. The lab is a cooperative venture with the Swiss Federal Office for Agriculture (OFAG) and the Swiss Federal Office for the Environment (FOEN). With its unique infrastructure, it not only facilitates WSL’s research (mainly of the new “Forest health and biotic interaction” Research Unit) but also attracts scientists from other institutions, such as Agroscope. In cooperation with a German university, salad plants infected with EHEC (enterohaemorrhagic *Escherichia coli*, a human pathogen) were investigated – only WSL could offer the infrastructure needed to conduct such a project subject to the required safety regulations.

Empa

For Empa, research and development in the area of Advanced/Additive Manufacturing (AM) plays a pivotal role:

- the official opening of the ETH Domain’s newly established Strategic Focus Area (SFA) Advanced Manufacturing, which is headed by Empa (cf. Chapter C.1.3);
- the consolidation of Empa’s cooperation with both the Canton of Bern and the Thun City Council in the area of AM and in 3-D printing;
- the establishment of a Competence Center for innovative metallic tools and processes at the Empa site in Thun and the expansion of its cooperation in 3-D printing with the “Switzerland Innovation” park site in Biel and with sitem-insel AG in Bern.

Empa also works with various Swiss Competence Centers in Energy Research (SCCERs) and leads the SCCER Future Energy Efficient Buildings & Districts (FEEB&D), where research will increasingly focus on systemic solutions, system integration and digitalisation over the next four years. Its vision is to develop solutions for the Swiss building stock, which should lead to a reduction of the sector’s environmental footprint by a factor of three by 2035 thanks to efficient, intelligent and interlinked buildings. Collaboration with industry is extremely close so that the SCCERs’ findings can be transformed into practical applications as fast as possible.

Various examples illustrate the successful collaboration and coordination in research and research infrastructures **within the ETH Domain**:

There are examples of initiatives which started within the ETH Domain and reach out to national coordination (e.g. the Strategic Focus Areas: Personalized Health and Related Technologies, Swiss Data Science Center, Advanced Manufacturing) while others were national initiatives from the outset (energy research) (cf. Chapter C.1).

- The ETH Zurich-based Center of Climate Systems Modelling (C2SM) coordinates the climate modelling and data analysis activities of several Swiss institutions involved in climate research. Members include Empa, WSL, MeteoSwiss and Agroscope.
- The Swiss Space Center is a joint initiative of EPFL, ETH Zurich and the Swiss Space Office, in which Empa and Eawag are also members. The Swiss Space Center contributes to the implementation of the Swiss Space Policy. It provides a service supporting academic institutions, RTOs and industry to access space missions and related applications, and promotes interaction between these stakeholders.
- Swiss Polar Institute (SPI): In 2017 the Swiss Polar Institute, launched by EPFL (leading house), WSL, ETH Zurich and University Bern in 2016, organised the ambitious Antarctic Circumnavigation Expedition involving more than 150 researchers from all over the world for nearly five months. This expedition gave approximately 25 researchers based at Swiss institutions – mainly at ETH Zurich, WSL and PSI but also the Universities of Geneva and Bern – the opportunity to gather unique measurements.

Energy Change Impact (ECI)

In line with the WSL tradition of engaging in research of high societal relevance, the Energy Change Impact (ECI) Research Programme supports and conducts projects with a high degree of inter- and transdisciplinarity. Such projects benefit strongly from cooperation, for instance, with ETH Zurich (ETH-PLUS (Planning of Landscape and Urban Systems)-project landscape perception, the Transdisciplinary Lab at the Department of Environmental Systems Science (energy wood Ukraine), Laboratory of Hydraulics, Hydrology and Glaciology (hydropower)), PSI (bioenergy), EPFL, Eawag and others (e.g. hydrological forecasts, integrated water management, multi-purpose reservoirs). Reaching beyond the ETH Domain institutions, the ECI Research Programme has established a national network targeting knowledge and technology transfer in large energy research programmes. This network connects experts from Swiss Competence Centers for Energy Research (SCCERs), National Research Programmes and other relevant initiatives. Apart from facilitating coordination and cooperation, it is a learning platform triggering activities across disciplines and sectors.

Appendix A.3

Institutional Accreditation

According to the Higher Education Act (HEdA), institutional accreditation is a requirement for an institution to be eligible to use the designation "University". The Agency of Accreditation and Quality Assurance³⁹ (AAQ) conducts the institutional accreditation procedures in Switzerland. The decision-taking body is the Swiss Accreditation Council. It awards the accredited higher education institutions a quality seal. The institutional accreditation procedure inspects the internal quality assurance system in a Higher Education Institution.

Institutional accreditation is scheduled for 2020 for ETH Zurich and 2021 for EPFL. Before accreditation became mandatory according to the HEdA, both Federal Institutes of Technology had participated on a voluntary basis in the evaluation by the former Swiss Center of Accreditation and Quality Assurance in Higher Education – ETH Zurich in 2008 and 2013; EPFL in 2006, 2010 and 2014. In addition, at EPFL study programmes are accredited by the French CTI (Commission des titres d'ingénieur).

Stakeholder Involvement

In all curriculum development processes, it is important that advice from the core stakeholders, i.e. actors from private industry and public sector who represent the occupational fields in which graduates from the corresponding programmes may be employed, is integrated in curriculum development. This applies not only to bachelor's and master's programmes but also to the continuing education offering. More precisely, the involvement of private industry is achieved as follows:

At ETH Zurich, professors are in close contact with industry, usually through research projects. Some of them started their career in industry. At several departments, an advisory board with representatives from industry is assigned the task of ensuring a continuing exchange with industry. For a number of study programmes, especially in engineering, an industry internship is mandatory while for the others it is highly recommended.

At EPFL, representatives of the main stakeholders are members of the advisory board of each curriculum. Since 2012, a mandatory industry internship is part of the curriculum of all engineering master's students. This has strengthened EPFL's relations with the industry while increasing graduates' employability and resourcefulness. Discussions are underway with the Swiss and cantonal governments to define specific training needs – e.g. in cybersecurity or in the digitalisation of the Swiss society (at every level: primary schools, high schools and vocational education).

At the research institutes, the continuing education offering is being developed and assessed in a continuous exchange with relevant stakeholders from the private sector, from professional associations and from public authorities.

Development and evaluation of curricula

ETH Zurich

At ETH Zurich there is a standard process for minor and major changes to curriculum design as well as for the development of a new curriculum:

The initiative for setting up a new curriculum or for the revision of an existing one can come from the professors or the students.

³⁹ <http://aaq.ch/en/>

It can be based on their own ideas or on the good practices of other departments and universities, or else on recommendations from a peer review, industrial partners or political circles.

- The development of curricula lies within the responsibility of a department. In this, the Teaching and Learning Committee plays a central role. It consists of 1/3 professors, 1/3 senior scientists and assistants, and 1/3 students.
- At the central level, management of the process is delegated by the Rector to the Pro-rector for Curriculum Development. He is supported by the central unit Educational Development and Technology (LET).
- The LET as well as the teaching specialists in the department support the process, whereas the rectorate is responsible for the legal aspects.
- Finally, a new curriculum or a revision of an existing curriculum has to be approved by the Executive Board of ETH Zurich.
- With respect to major changes of an existing curriculum or the development of a new curriculum, core stakeholders from private industry and public administration as well as the Executive Board are involved at an early stage.

At ETH Zurich curricula are evaluated on the occasion of a peer review by a department, i.e. every 6–7 years.

- The process is identical to that of peer reviews generally: the department first produces a self-evaluation report, and this is followed by a site visit by an international review panel. The findings of the biannual graduate surveys by the Federal Statistical Office – another instrument for the evaluation of teaching and learning – is considered in both the self-evaluation report and the site visit.
- The panel establishes the experts' report, to which the respective department responds in a comprehensive statement.
- The Executive Board of ETH Zurich finally takes its decisions on the basis of the recommendations by the experts and the comments by the department, and submits the report to the ETH Board.

EPFL

At EPFL, the school or college presents the idea for the introduction of a new curriculum to the EPFL directorate.

- In close collaboration with the Vice-Presidency for Education, the chosen project manager prepares a detailed analysis according to the official guidelines on how to create a new curriculum.
- The latter requires a good knowledge and an overview of existing offers worldwide, an analysis of the strengths of EPFL in the domain at stake, as well as a study of the needs of industry and the future job market, including a forecast of the required infrastructures.
- The complete analysis is finally presented to the EPFL directorate for approval.

The evaluation of curricula is organised along the following lines:

- The Vice-Presidency for Education together with the Quality Office manages this accreditation.
- For each curriculum there is an advisory board composed of representatives from industry as well as external academics, which helps the section responsible in reviewing and adapting the general content.

- In each section, an academic committee, including an external member, helps to review the courses as well as examination content.
- All the courses are evaluated every year by the involved students. A two-stage procedure is in place: in the first step an indicative evaluation is carried out, then, if required, an in-depth evaluation completes the analysis.
- A pilot project has been launched to evaluate all bachelor's and master's cycles. Master's students are questioned about their bachelor's studies at EPFL, and alumni on their master's studies.

Graduate Surveys

ETH Zurich participates regularly in the graduate survey of the Federal Statistical Office (FSO); the questionnaire is amended with ETH Zurich-specific questions and provides very valuable information for the revision of curricula as well as for monitoring career paths. In 2015 the first panel survey revealed the situation of ETH Zurich graduates after 5 years. Some of the findings are:

- One year after graduation, 90 % of all master's graduates and 76 % of doctorate holders work in Switzerland, which is similar after five years (master's 87 %, doctorate 79 %). It is noteworthy that >65 % of the all international students with an ETH Zurich master's degree (71 %) or doctorate (65 %) are working in Switzerland, while after five years the figures are 64 % for master's graduates and 67 % for doctorate holders.
- Five years after graduation, 31 % of master's graduates and 56 % of doctorate holders occupy executive positions (primarily lower management, some in middle management).
- Five years after graduation, 5 % of doctorate holders have been appointed as professors.

At **EPFL**, the Career Center runs its own annual workplace entry survey⁴⁰ to assess the professional situation of graduates in the year that follows graduation. With regards to international graduates

- 56 % of international master's graduates work or pursue doctoral studies in Switzerland.
- 60 % of international doctoral graduates work in Switzerland.

Employability is measured according to several parameters

Class of 2016 working in Switzerland	Master's	Doctorate
Employment rate	91.3 %	93.2 %
Net employment rate	89.0 %	N.A.
Average number of applications before landing a job	12	19
Average time before landing a job	9.2 weeks	15.1 weeks
Median time before landing a job	6 weeks	12 weeks
Average number of jobs landed	1.6	1.6

⁴⁰ <http://carriere.epfl.ch>

A.4

Structure, Cooperation within the ETH Domain and Strategic Alliances

Excerpt from the Mandate:

“What is the assessment of structures and cooperation within the ETH Domain, as well as with external institutions with which it maintains strategic alliances, from the viewpoints of efficiency and efficacy? Is there potential for optimisation?”

A.4 Structure, Cooperation within the ETH Domain and Strategic Alliances

Assessment by the ETH Board

Assets

a) Structure of the ETH Domain

- The current structure of the ETH Domain as described in the ETH Act (two Federal Institutes of Technology and four research institutes) has proven successful in general for achieving the ambitious strategic objectives of the Federal Council and for making a vital contribution towards Switzerland's competitiveness and economic development (cf. Chapter A.1 and A.2). Nevertheless, with the goal of increasing the ETH Domain's ability to react promptly to current and upcoming societal challenges and to provide solutions for specific needs of the country, the ETH Board launched a process to rethink the governance and structure of the ETH Domain.

b) Cooperation within the ETH Domain

- The six institutions are cooperating within the ETH Domain (cf. examples for collaborations in the field of teaching, research or administration). Such collaborations are mutually beneficial for the institutions involved. In many cases, the cooperation with regional, national or international partners (i.e. universities, private industry, national governments) is as important as cooperation within the ETH Domain.

c) Strategic alliances

- To make use of scientific synergies, the ETH Domain institutions cooperate in specific fields of research and innovation with national technological centres of expertise and research institutes which are federally supported under Article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA)⁴¹. In most cases, these strategic alliances are fruitful cooperation ventures in specific fields of research and innovation and are mutually beneficial for the institutions involved.

Challenges

a) Structure of the ETH Domain

- The globalisation of science and the economy, the digital revolution and massively increased investment in science and education by certain large nations present major challenges for the ETH Domain institutions, as do limitations in terms of both human capital and financial resources. These factors challenge the institutions' ability to thrive, attract the world's best talent, perform high-impact research and provide first-class education for future students. The ETH Domain faces unprecedented demand to provide both a sound scientific basis and sustainable solutions to increasingly complex environmental and technological challenges which reflect pressing societal needs. Public and political stakeholders' expectations of rapid solutions are continually growing, as is the need to invest the funds provided to the ETH Domain efficiently and with the greatest possible impact for Switzerland. Therefore, the ETH Board is rethinking the governance and structure of the ETH Domain with the goals of best meeting these demands and remaining internationally competitive in the long term.

"What is the assessment of structures and cooperation within the ETH Domain, as well as with external institutions with which it maintains strategic alliances, from the viewpoints of efficiency and efficacy? Is there potential for optimisation?"

⁴¹ Federal Act on the Promotion of Research and Innovation (RIPA), of 14 December 2012 (as at 1 January 2018)

b) Cooperation within the ETH Domain

- It is a constant challenge to demonstrate to policy-makers that some duplication within the ETH Domain (in certain research fields, and notably between ETH Zurich and EPFL) is necessary, is politically desirable in the multilingual Swiss higher education sector and produces added value (e.g. study programmes for the education of a larger number of urgently needed highly qualified specialists in the STEM fields; accelerated advancement of research in fields with societal relevance).

c) Strategic alliances

- For a strategic alliance to be mutually beneficial, the members of both partner institutions and of the management boards need to be strongly committed to making the best possible use of synergies.

A.4.1 Structure of the ETH Domain

In order to respond to an increasingly dynamic environment, all institutions of the ETH Domain must agree on overarching goals. Specifically, the ETH Board emphasises that the institutions of the ETH Domain must be able to:

- push their already excellent performance to even higher levels;
- maintain their excellence in teaching and internationally competitive research;
- become more agile and creative in their ability to embrace new domains of science and technology;
- intensify collaboration and foster interdisciplinary projects or centres to address complex problems;
- facilitate a rapid translation of research insights into technological solutions to benefit industrial exploitation and ultimately also society;
- increase their reputation and visibility internationally in order to attract, retain, train and foster the best scientific and technical talent, thus securing Switzerland's competitiveness in increasingly globalised scientific endeavours;
- gain more flexibility for raising and using third-party funds from private sources in order to finance timely action on unexpected or emerging topics;
- meet the highest international standards of scientific integrity and ethical behaviour.

The ETH Board is rethinking the governance and structure of the ETH Domain in an open-ended process (i.e. without any prejudging of the outcome) and aims to preserve the ETH Domain's leading role over the next few decades. The suitability of the ETH Domain's overall governance and financial framework for fostering international competitiveness – as laid down in the ETH Act – has been a topic of previous intermediate evaluations. Term of reference A.4 in the present intermediate evaluation asks whether the internal structures and level of cooperation within the ETH Domain are adequate to meet these goals. The ETH Board's current rethinking process shall provide a basis to address this question.

A.4.2 Cooperation within the ETH Domain

Cooperation within the ETH Domain is illustrated by selected examples of teaching and research (joint professorships), research infrastructures (ESI Platform, NEST, SPC) and administration (Lib4RI, SAP4Four). These examples also show that the cooperation goes well beyond the ETH Domain and includes other institutions from the higher education sector and from the private sector. Further examples of cooperation in teaching are presented in Chapter A.1.1, section on teaching contributions by the research institutes and in Chapter A.3.2, section on teaching collaboration and coordination within the ETH Domain. Excellent examples of cooperation in research are the Strategic Focus Areas (SFAs) presented in Chapter C.1.

Figure 17: Joint professors between ETH Zurich or EPFL and the Research Institutes

	PSI	WSL	Empa	Eawag
ETH Zurich	19	8	12	14
EPFL	9	3	4	4

Figure 17 presents all joint professors of ETH Zurich, EPFL und the research institutes (including full, associate, assistant, and adjunct professors) as of October 2018 (in headcounts). The Directors of the research institutes are joint professors at ETH Zurich and EPFL and thus counted at each school.

ESI Platform

Energy Strategy 2050 will lead to the expansion of new renewable sources such as solar energy, wind power, and energy from biomass and to a growing need to integrate these sources into the Swiss energy system. With the Energy System Integration (ESI) Platform, PSI offers research partners and industry an experimental platform where promising approaches can be tested in all their complexity and interrelations. As a first step from the laboratory to industrial application, the ESI platform offers the possibility to investigate the technical feasibility of different processes, e.g. energy production from biomass or storage of surplus electric power by conversion into energy-rich gases such as hydrogen or methane ("power-to-gas technology"). These gases can also be used as renewable fuels in the mobility sector, as currently tested in close collaboration between the ESI platform and "move", the demonstrator for future mobility at Empa. The ESI platform is open to all partners from the ETH Domain, especially to collaborative projects of the Swiss Competence Centers for Energy Research (SCCERs).

NEST

In the "NEST" modular research building on the Empa campus in Dübendorf, research institutions, companies and the public sector have the opportunity to validate and further develop new materials and technologies in a real-world environment. Innovations from the construction and energy sector are installed in "units", which are integrated into NEST in a "plug-and-play" mode and which serve as residential or office modules.

Several NEST units are developed in close collaboration with or led by researchers from the ETH Domain's institutions, namely:

- **SolAce**, where EPFL researchers and their industrial partners investigate (among other things) the capture of solar energy and daylight by the building envelope or multi-functional facade technologies that will be implemented to achieve an Energy-Plus and Low Carbon combined working/living space.

- **Vision Wood**, which is home to a wealth of timber-based innovations. The unit was developed by Empa's Applied Wood Materials laboratory and in collaboration with colleagues at ETH Zurich. It combines the latest developments in wood research with expertise in modern wood construction.
- **DFAB HOUSE** is a collaborative demonstrator of the National Centre of Competence in Research (NCCR) "Digital Fabrication". As part of the full-featured building project, researchers from eight ETH Zurich institutes work together with experts from industry in a unique way to explore and test how digital fabrication can change the way we design and fabricate buildings.
- **Water Hub**, where Eawag tests systems that make the most efficient and versatile use of water and wastewater. Eawag is about to install and operate a new urine treatment reactor in NEST to assist the commercialisation of a urine-derived fertilizer and to develop a new approach on greywater that has huge potential for reducing the use of fresh water.

NEST thus significantly accelerates the process of innovation in the building sector – a notoriously conservative sector – and helps launch innovative building and energy technologies on the market much faster than before.

Swiss Plasma Center

The Swiss Plasma Center reinforces Switzerland's international standing and impact in plasma and fusion research. The state-of-the-art infrastructures that are currently developed, focusing primarily on fusion energy research, enable Switzerland – in the framework of its association with Horizon 2020 and Euratom, to fulfil its role and obligations on the way to fusion energy in the broader context of Europe, Euratom and ITER. The Center brings together contributions from EPFL, ETH Zurich/CSCS and PSI. Based on projected funding levels, the Swiss Plasma Center will help Switzerland stay at the cutting edge of fusion research and associated trans-generational education for at least the next two decades, when the first ITER high-performance plasma results will become available.

Lib4RI – Library for the Research Institutes of the ETH Domain

After operating a joint library for Eawag and Empa in Dübendorf since 2006, the four research institutes merged their libraries organisationally to form "Lib4RI – Library for the Research Institutes within the ETH Domain: Eawag, Empa, PSI & WSL" in 2011. This has since resulted in sustainable positive effects. In particular, the new size of the library has allowed a division of work within the library team while retaining the close contact to the scientists and still enabling agile reactions to their needs. The ongoing change from print to electronic resources was managed professionally, increasing the number of full-text downloads by a factor of two within five years, while the library's budget remained constant. Services for the scientists were significantly improved and enhanced, including an institutional repository that now contains more than 40,000 items and a well-received training programme for junior scientists, notably on topics concerning scholarly communication.

SAP4Four – SAP-Platform for the Research Institutes of the ETH Domain

In 2012 (Empa: 2013), the four research institutes were migrated to a common SAP platform hosted by the Federal Office of Information Technology, Systems and Telecommunication. This replaced the legacy V-Soft platform used by PSI, Eawag and WSL as well as Empa's internal SAP system. The migration enabled the research institutes to meet the challenges posed by the application of the International Public Sector Accounting Standards (IPSAS) in order to fulfil governance and internal control system (ICS) requirements. The institutes benefit from synergies by sharing a common platform that would not be affordable individually. The SAP platform allows the research institutes to integrate external systems via interfaces, to promote externally driven developments such as the implementation of e-billing and to offer their researchers access to relevant data via BI (Business intelligence) reports. Additionally, workflows have been implemented to facilitate efficient processing of invoices and procurement requests with system-supported approval procedures.

A.4.3 Strategic Alliances

To make use of scientific synergies, the ETH Domain institutions cooperate in specific fields of research and innovation with national technological centres of expertise and research institutes receiving federal support under Article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA)⁴². ETH Zurich maintains strategic alliances and cooperates with the Institute for Research in Biomedicine (IRB) and Inspire AG, while EPFL cooperates with the Centre Suisse d'Electronique et de Microtechnique (CSEM), Idiap Research Institute and the Swiss Tropical and Public Health Institute (Swiss TPH).

These institutions are periodically assessed by the Swiss Science Council (SSC); their latest evaluation occurred in the context of the funding requests for the period 2017–2020⁴³. The conclusions of these evaluations are integrated in the descriptive paragraphs below.

Institute for Research in Biomedicine (IRB), Bellinzona

In the last 18 years, the IRB has gained international recognition for fundamental discoveries with translational potential in the fields of biomedicine and human immunology. A strategic alliance with ETH Zurich was established in 2009 with the creation of a chair of Human Immunology at the ETH financed by the Helmut Horten Foundation and was strengthened in 2017 with a chair of Medical Immunology with an associated research group in Zurich. The cost-effective alliance currently involves several IRB and ETH Zurich group leaders and is based on collaborative projects, sharing of facilities and involvement in teaching at all levels (bachelor's, master's, postgraduate) at ETH Zurich and in the new faculty of Biomedical Sciences at USI. The SSC report states that the IRB has proven that it can translate financial support into cutting-edge research, recruitment of young talents and contributions to Swiss higher education and that the ETH Zurich/IRB alliance is a mutually beneficial relationship.

Inspire AG, Zurich

Inspire AG is the strategic partner of ETH Zurich for KTT to Swiss industries in the field of manufacturing. Inspire carries out applied research with the support of several ETH Zurich professorships. According to a recent assessment by the SSC, Inspire's uniqueness lies in the combination of the clear focus on SMEs and the scientific excellence provided by ETH Zurich and is mutually beneficial for both partners. SSC strongly endorses the recent broadening of Inspire's

⁴² Federal Act on the Promotion of Research and Innovation (RIPA), of 14 December 2021 (as at 1 January 2018)

⁴³ Rapport du Conseil suisse de la science et de l'innovation à l'attention du Secrétariat d'Etat à la formation, à la recherche et à l'innovation https://www.swir.ch/images/stories/pdf/fr/2016_11_15_Rapport_CSSI_Art_15_LERI_publ_def_CORR.pdf

scope to include future-oriented fields such as additive manufacturing, machine learning and design of IoT products.

Centre Suisse d'Electronique et de Microtechnique (CSEM), Neuchâtel (headquarters)

CSEM is a research and technology organisation and a public-private partnership created in 1984. EPFL and CSEM have several areas of common interest, e.g. microsystems, surface engineering, systems, ultra-low power integrated systems, photovoltaics and energy management. Thanks to the geographical and thematic proximity of CSEM and EPFL Neuchâtel, the two parties developed a fruitful relationship, especially in the area of photovoltaic and micro-electro-mechanical systems (MEMS). Examples of collaborative activities include joint research projects (e.g. Innosuisse, Nanotera), supervision of students, teaching by CSEM staff at EPFL, a joint professorship, and the Micromanufacturing Science and Engineering Center (M2C). The CSEM Scientific Advisory Board (SAB) is chaired by EPFL. Both partners clearly benefit from this alliance, which has also been emphasised in the SSC report.

Idiap Research Institute, Martigny

Created in 1991, the Idiap Research Institute is a non-profit foundation co-financed by the Federal Government, the Canton of Valais, and the City of Martigny. The institute is internationally recognised as a centre of expertise in the areas of speech processing, computer vision, information retrieval, biometric authentication, multimodal interaction and machine learning. As pointed out in the SSC report, Idiap has a great entrepreneurial spirit and greatly contributes to the education of young scientists in important emerging fields. Several Idiap scientists hold an EPFL academic title, two of them being professors at EPFL. Idiap scientists are actively involved in undergraduate and graduate teaching at EPFL and the supervision of EPFL doctoral students. The cooperation between EPFL and Idiap is beneficial to both partners and management of the two institutions is currently exploring ways to intensify their interactions.

Swiss Tropical and Public Health Institute (Swiss TPH), Basel

Created in 1943, the Swiss TPH is a leading institute in tropical diseases and public health with a particular focus on low- and middle-income countries. Associated with the University of Basel, the Swiss TPH combines research, services, and education as well as training at the local, national and international level. The Swiss TPH's partner at EPFL is the Global Health Institute (GHI). Collaboration activities between the two institutes focus on four areas: development and clinical testing of tuberculosis drugs, other mycobacterial diseases, development and maintenance of a study platform for personalised and public health, and education (supervision of student projects, MOOCs). The SSC report indicates that while several research groups from both institutions are very interested in collaborating, the institutional relationship has not developed to the expected extent. The EPFL management will review the situation together with the Swiss TPH management.

Institut de Recherche en Ophtalmologie (IRO), Sion

Due to a lack of overlapping interest and collaboration between EPFL and IRO, it was jointly agreed to discontinue the strategic alliance after the period 2012–2016.

A.5

Cooperation with Cantons

Excerpt from the Mandate:

“What is the assessment of the ETH Domain’s cooperation efforts with various cantons, which have been expanded in recent years? Is the cost-benefit ratio (finances, steering, autonomy, academic responsibility, etc.) positive for the ETH Domain? What is the assessment of these cooperation arrangements in the context of the coordination of the entire Swiss higher education sector and the needs of the Swiss economy and society?”

A.5 Cooperation with Cantons

Assessment by the ETH Board

Assets

Different historical, political or scientific reasons have led to the current presence of the ETH Domain institutions in 13 Swiss cantons. The ETH Board considers that geographic expansion can offer opportunities compatible with strategic priorities and objectives of the ETH Domain. In many cases, geographic expansion of ETH Domain institutions has been supported by the willingness of political authorities (such as cantonal governments), other higher education partners and private companies to substantially and sustainably contribute in terms of resources and investments to the realisation of the respective projects.

- The cooperation of the ETH Domain institutions with the cantons and their higher education institutions strengthens the ETH Domain and the entire Swiss higher education system through making the best possible use of complementarities and synergies. Cantons can benefit in terms of additional employment perspectives, returns for the local economy and an innovation boost in the respective region.
- The ETH Domain's regional embedding is an important element explaining the deeply rooted support it receives throughout Switzerland.
- There are differences in the approaches within the ETH Domain regarding the cooperation and interactions with the cantons, reflecting diversity in opportunities as well as political, economic and cultural differences in Switzerland.
- In the recent past, the institutions have not developed additional sites but have strengthened their existing locations.

Challenges

Regarding external sites, the ETH Board identifies the following challenges:

- The physical distance between the main campuses and external locations requires additional efforts in terms of integration, scientific interactions, administration and management.
- The involvement of different parties (such as cantons or other universities) may create new dependencies, and other actors may have the leadership of some development projects, possibly leading to interdependence with local policy-making.
- Communication with cantons wanting to establish new ETH Domain sites on their territory is politically sensitive and needs specific consideration.
- Financial contributions from cantons (e.g. for new ETH Domain sites) may compete with the financing of the canton's own academic institutions. This could diminish local acceptance and support for the respective institution of the ETH Domain.

"What is the assessment of the ETH Domain's cooperation efforts with various cantons, which have been expanded in recent years? Is the cost-benefit ratio (finances, steering, autonomy, academic responsibility, etc.) positive for the ETH Domain? What is the assessment of these cooperation arrangements in the context of the coordination of the entire Swiss higher education sector and the needs of the Swiss economy and society?"

A.5.1 Cooperation with Cantons

The ETH Domain is strongly anchored throughout Switzerland (cf. Figure 2, Chapter A and Figure 18, Appendix A.5). The cooperation of the ETH Domain institutions with the cantons and their higher education institutions strengthens the ETH Domain and the entire Swiss higher education system as the best possible use is made of the system's complementarities and synergies. There are differences in the approaches within the ETH Domain regarding cooperation and interactions with the cantons; these reflect the diversity in terms of opportunities and the political, economic and cultural diversity of Switzerland.

A.5.2 Criteria for Cooperation

In order to ensure the sustainability of institutional cooperation and to minimise strategic risks, the ETH Board has noted the criteria the institutions want to follow when engaging in new national or international cooperation. While the first three criteria are considered mandatory, the latter two are additional favourable elements.

- Academic coherence: Each geographic development project must ensure that it is compatible with the institution's strategy. Developing a new focal area around particular topics at a new location must generate added value that could not be generated if the corresponding focus were developed at the institution's main campus. Such added value can result from the peculiarities of the regional context (such as environmental, political, or cultural aspects) as well as from particular opportunities related to the presence and the excellence of academic or economic partners on site.
- Academic responsibility: The institution must be granted full academic responsibility with regard to the projects it facilitates within the region. This is of particular importance when chairs and other staff positions are financed by the canton and/or by private funders. It entails full freedom with regard to recruiting scientific staff (professors, researchers) and an assurance that they are granted full academic autonomy. It also means that the institution must be entitled to (re)integrate the corresponding scientific staff to its main campus should the respective antenna project fail or be interrupted.
- Critical mass and international competitiveness: The institution engages in collaboration projects with the aim of increasing its capacity to deal with scientific issues where the ETH Domain is in global competition with the world's leading scientific institutions. Critical mass at the regional locations must be guaranteed. Thus, a geographic expansion project must contribute added value in terms of Switzerland's competitiveness and innovative capacity and thus meet the economic and political actors' expectations of the ETH Domain.
- Financial agreements: The financial aspects of the collaboration with a canton (or a country) and the distribution of costs must be clearly defined from the outset (e.g. with regard to the infrastructure investments a canton (or a country) is willing to contribute). If applicable, this also entails possible schemes for the co-financing of operational costs. Not least, financial agreements must also extend to the eventuality of the project failing.
- Coherence with regional competencies and the regional industrial characteristics: The scientific issues on which a regional branch focuses must be relevant with regard to the region's industrial and economic characteristics. Such proximity makes it possible to generate additional benefit in terms of innovation as well as knowledge and technology transfer, contributing to the region and to the achievement of the ETH Domain's strategic goals. At the same time, it favours the establishment of additional networks or strategic partnerships with economic actors from the respective region (e.g. through funding of professorships).

A.5.3 Assessment of External Locations of the ETH Domain Institutions

Based on the recommendations of the Expert Committee of the Intermediate Evaluation 2015 (cf. Chapter F, Recommendation 5), the ETH Domain institutions recently assessed the benefits and costs of their interactions with cantons and reported the outcome to the ETH Board⁴⁴. The establishment of new external locations often entails the implementation of expansion opportunities that would not be possible on the institutions' main sites (for example the launch of new research fields or activities). Benefits associated with the establishment or development of external sites are different for every single case. The following examples of benefits do not constitute an exhaustive list but represent an important part of the overall benefits cited in the reports of the institutions.

- One of the main advantages is to bring the ETH Domain institutions closer to other universities and research institutions, as well as to public or private actors of interest. This can include easier access to existing professional expertise, students and/or infrastructures. Resulting collaborations are often very successful and chime with the wish to reinforce collaborations and interactions with other actors within the Swiss higher education sector or research community.
- Thanks to the institutions' external sites, the ETH Domain also has better connections to specific industrial partners, enabling notably a more efficient knowledge and technology transfer (e.g. in the context of the creation of the decentralised "Switzerland Innovation" park).
- The ETH Domain also profits financially from the resulting direct interactions with the governments of different cantons. Cantons (and cities/communities) often participate in covering costs of the ETH Domain's external sites in terms of infrastructure, personnel costs (including joint professorships) or real estate, by funding projects, or through other favourable initiatives. These financial benefits vary from site to site.
- Geographical or environmental aspects can also be important components of the strategies to establish or maintain external sites. The institutions and research groups focusing on geographical and environmental research often require specific conditions that are not available on their main campuses. External sites provide excellent opportunities for field-based research, education and outreach, and are often necessary to fulfil certain research mandates of the federal offices. Furthermore, some areas in Switzerland have spatial characteristics that allow better accommodation of new research activities than on main sites.

The institutions' contributions to the external sites constitute an important aspect in the interactions with the different cantons.

- A substantial proportion of the costs is covered by the ETH Domain, including new professorships and other employment positions.
- The benefits for the cantons are diverse, but in all cases include employment prospects for the inhabitants and benefits for the local economy.

Challenges exist regarding external sites.

- These include the physical distance between the main campuses and external locations, requiring more effort in terms of integration, scientific interactions, administrative requirement and support, and possibly in terms of management.

⁴⁴ The ETH Board took note of the individual reports (ETH Zurich, EPFL, WSL, Empa, Eawag) on 4/5 July 2018. They are available on request.

- Furthermore, the involvement of different parties (such as cantons or other universities) may create new dependencies and other actors may have the leadership of certain development projects, possibly resulting in interdependence with local politics.

The establishment of the ETH Domain institutions in the different cantons has so far led to fruitful interactions with cantons, cantonal universities, universities of applied sciences and other interested partners, and has proceeded well in line with the ETH Domains' strategic objectives. Furthermore, external locations favour collaborations between the institutions of the ETH Domain themselves and can ease the creation of joint professorships (cf. Chapter A.4). The success of external locations (in terms of scientific results, publications, collaborations and transfer of technology) indicates an overall positive outcome.

A.5.4 Examples of Fruitful Cooperation with Cantons and Cantonal Institutions

ETH Zurich – University of Zurich – University of Basel – University hospitals

Institutional cooperation between ETH Zurich and the University of Zurich (UZH) has been running very well for a long time, has led to an enormous extension of the range of subjects and substantially enhances the international competitiveness of Zurich as a university city. At present, institutional cooperation between ETH Zurich and UZH extends to 22 double professorships, four joint institutes, four joint Competence Centers (one of which is also with the University of Basel), shared research infrastructures, four joint master's programmes (joint degrees; one of them again with the University of Basel), various degree courses offered in close cooperation (complementary degree courses), free access to the courses of both universities for students, several joint doctoral programmes (one of them again with the University of Basel), as well as a variety of services for students and staff (such as the library network, a language centre, a childcare foundation in Zurich's university quarter, etc.).

In the coming years, it is planned to strengthen cooperation in the field of medicine in particular with the following crucial elements:

- The umbrella organisation University Medicine Zurich, established by ETH Zurich, the University of Zurich and the Zurich University Hospitals in 2012, which aims to interlink clinical medicine, basic biomedical research and engineering sciences to promote transnational research and training.
- The Wyss Translational Center Zurich (WTZ) of ETH Zurich and UZH, which was set up in 2014 thanks to a USD 120m donation by Hansjörg Wyss. It promotes cooperation between researchers from the engineering sciences and from medicine with the purpose of efficiently translating insights from basic and preclinical research into new medical therapies and innovative products.
- ETH Zurich's novel bachelor's course in medicine, which was launched in autumn 2017 and is offered in cooperation with the Universities of Zurich and Basel and the Università della Svizzera Italiana (USI) and whose range of courses will be supplemented by UZH and further partners. The partner universities will admit graduates of ETH Zurich's bachelor's course to their master's programmes.
- Netzwerk Medizin: cooperation among several universities with the aim of triggering the constant further development of the medical curricula.

- The Personalized Health Alliance Zurich–Basel, within the scope of which ETH Zurich, UZH, the University of Basel and the University Hospitals of Zurich and Basel are jointly developing project clusters around various clinically relevant questions at the interface between medicine, natural and engineering sciences. The alliance constitutes one pillar of the nation-wide Swiss Personalized Health Network (SPHN).
- The Center for Precision Medicine, which was newly set up together with the University of Zurich and Zurich's University Hospitals in 2018.

EPFL – Collaboration with neighbouring institutions has long provided EPFL with opportunities to reinforce activities in key thematic areas and to create a critical mass in areas of national importance. The remarkable growth in advanced technology activities in the Lake Geneva region has been in part fuelled by joint initiatives with, among others, the Universities of Lausanne and Geneva and with several University Hospitals. Of particular note are:

- Within the Personalized Health initiative, the Health 2030 collaboration between EPFL, the Universities of Lausanne, Geneva and Bern, Lausanne University Hospital, the Geneva University Hospitals, Inselspital Bern and the Swiss Institute of Bioinformatics has resulted in the setting up of a genome sequencing and analysis platform.
- Collaboration with Lausanne University Hospital, the University of Lausanne, the University of Geneva, the Geneva University Hospitals and the Ludwig Cancer Research Centre at the Swiss Cancer Centre Lausanne. Under the "Agora" banner a unique environment has been created in which pluridisciplinary teams will collaborate at the interface between research and clinical practice. The first teams moved into the new building in October 2018 and will be joined by close to 300 specialists.
- Interaction with the Clinique Romande de Réadaptation (CRR) SuvaCare in Sion has led to several joint research initiatives with EPFL laboratories and to the embedded presence of teams of EPFL specialists on the CRR premises.
- The Centre for Biomedical Imaging at EPFL was established in collaboration with the University of Lausanne, the University of Geneva, the Lausanne University Hospital and the Geneva University Hospitals. It provides cutting-edge resources and has grown into a potent resource for researchers throughout the region.

PSI – Cantons, cantonal Universities, University Hospitals

- Gantry 3 (inauguration of the new treatment unit in May 2018): The capacity for proton therapy at PSI, the only place in Switzerland where this therapy is possible, is expanded through a joint project between University Hospital Zurich, University of Zurich and PSI. Financial support was provided from the lottery fund of the Canton of Zurich. (Gantry 2 was financed in a similar way by the Canton of Aargau; CHF 20m per Gantry).
- Proton therapy: numerous clinical collaborations⁴⁵, e.g. for the treatment of ocular tumours (OPTIS programme) a close clinical collaboration with the Ophthalmic Hospital Jules-Gonin in Lausanne has been established. All patients are seen at the hospital in Lausanne first to evaluate the need of proton therapy. If there is such a need, they undergo a preparatory surgical intervention before being referred to the Center for Proton Therapy at PSI.
- The close cooperation between the Canton of Aargau and PSI for developing the concept of PARK INNOVAARE was one of the most important factors for the successful application as network location for "Switzerland Innovation" park in 2014.
- SwissFEL: Phase 1: Canton of Aargau contributed CHF 30m out of about CHF 300m total cost. Phase 2 of SwissFEL (ATHOS Beamline): Canton of Aargau contributes CHF 4m out of total about CHF 44m.

⁴⁵ <https://www.psi.ch/protontherapy/clinical-collaboration>

WSL – Cantons, University of Applied Sciences

- SLF – Canton of Graubünden: After the rockfall at Pizzo Cengalo followed by debris flows in Bondo (Graubünden) in August 2017, two experts from WSL's external site in Davos (SLF) were appointed to the canton's expert group that analysed this rare event of cascading processes and provided the authorities with information for their future decisions. Being situated in the Alps, SLF is a trustworthy and authentic partner for alpine cantons (and countries) for research into and management of natural hazards.
- WSL Cadenazzo – Canton of Ticino: Italian-speaking scientists from WSL's site in Cadenazzo played an important role in managing the chestnut gall wasp, an invasive species causing massive harm to Chestnut trees. Being at the place where the invasion took place, the researchers saw the first symptoms and could observe the pest's dynamic. Their good contacts to officials in Ticino and Italy and their local knowledge aided their success in researching this wasp. Many invasive species enter Switzerland from the South, so Swiss society will profit repeatedly from WSL's site in Cadenazzo.
- WSL – Bern University of Applied Sciences: For WSL, the School of Agricultural, Forest and Food Sciences (HAFL) at Bern University of Applied Sciences is an important cantonal partner. WSL and HAFL manage joint projects. Beside or rather before such official co-operations, the growing number of alumni and alumnae from WSL going to HAFL and vice versa helps to establish close relations. For example, WSL offers a guest workplace to an HAFL professor who used to work at WSL before his appointment at HAFL, and thus maintains close contact with him.

Empa – Cantons, hospitals, Universities of Applied Sciences

- Successful consolidation of Empa's cooperation with the Canton of Bern and the City of Thun to establish a Competence Center in the areas of Advanced Manufacturing, 3-D printing, innovative metallic tools and processes at the Empa campus in Thun, as well as the expansion of cooperation in 3-D printing with the "Switzerland Innovation" park in Biel/Bienne and with sitem-insel AG in Bern.
- Ongoing cooperation with University Hospital Zurich in the framework of the "Zurich Heart" research initiative together with ETH Zurich and the University of Zurich as well as to develop smart sensors for the surveillance of wound healing processes (in cooperation with the Centre Suisse d'Electronique et de Microtechnique (CSEM) in Neuchâtel).
- Increasingly close cooperation with the St. Gallen Cantonal Hospital in a number of areas such as dermatology, where a novel, fibre-based drug delivery device for the treatment of psoriasis is being developed, and pneumology/sleep research in order to develop a multi-sensor device to continuously assess breathing abnormalities during sleep (sleep apnoea) to be used in a home setting.
- Development of the Solar Fitness and Wellness unit in NEST, a fitness and wellness facility powered entirely by solar energy and the power generated by its users' physical exercise, in cooperation with the Swiss-Liechtenstein building technology association (suissetec) together with the University of Applied Sciences and Technology Buchs (NTB) and Lucerne University of Applied Sciences and Arts.
- Development of the eDumper, the largest electric vehicle in the world, which has been in operation in a quarry in Péry in the Bernese Jura since April 2018, together with industry partners, the Bern University of Applied Sciences BFH and the University of Applied Sciences and Technology Buchs (NTB).

Eawag – University of Bern

- Since 2004 Eawag's Department of Fish Ecology and Evolution in Kastanienbaum has been closely linked to the Aquatic Ecology Division of the Institute of Ecology and Evolution at the University of Bern by a joint professorship. Joint appointments with Eawag are based on Eawag's contributions to facilities (e.g. office and laboratory space), personnel and start-up support for joint professors.
- In 2011 a new area of expertise in policy analysis was set up at Eawag's Department of Environmental Social Sciences by a joint professorship with the Institute of Political Science at the University of Bern. This professorship is also affiliated to the Oeschger Centre for Climate Change research.

Appendix A.5

Figure 18: Main and external sites of the ETH Domain institutions in Switzerland

Institution	Main site: City, canton	External sites: City, canton(s)	Estab- lished ⁴⁶	Main focus of external sites
ETH Zurich	Two campuses (Centre and Hönggerberg), Zurich, Canton of Zurich	Department Biosystems Science and Engineering, Basel, Canton of Basel-Stadt	2007	The mission of D-BSSE is the understanding, rational design and programming of complex biological systems from the nanoscale up to whole organisms. The department links ETH Zurich with academic institutions and industry in the Basel area.
		Swiss National Supercomputing Centre (CSCS), Lugano, Canton of Ticino	1991	CSCS provides high-performance computing capacity for the Swiss scientific community.
EPFL	EPFL Lausanne, Lausanne, Canton of Vaud	EPFL Fribourg, Smart Living Lab (SLL), Fribourg, Canton of Fribourg	2014	As a centre for the habitat of the future, the SLL brings together researchers and teachers in energy optimisation, integrated design, building technology and sustainability. The development of demonstrator installations is at the heart of the Lab's activity. Keywords: sustainable architecture, construction technology
		EPFL Geneva, Campus Biotech, Geneva, Canton of Geneva	2013	The founding partners' shared vision: to unite fundamental, technological and clinical research in the fields of neuroscience, global health and digital health in a transdisciplinary centre closely linked to industrial and entrepreneurial partners. Keywords: neuroscience, neuroengineering, bioengineering, neuroprosthetics
		EPFL Neuchâtel, Microcity, Neuchâtel, Canton of Neuchâtel	2008	Excellence in education, fundamental and applied research, technology transfer and industrialisation strategies in all things related to the infinitely precise. Microcity is a pole of innovation based on the industrial fabric of the Neuchâtel region. Keywords: microengineering, nanotechnology, microfabrication
		EPFL Valais-Wallis, Energypolis, Sion, Canton of Valais	2012	A pole of excellence for research and innovation in energy, health and the environment, based on long-standing collaborations between EPFL and the Canton. The site will soon expand with the creation of a centre for alpine and extreme environments. Keywords: industrial energy, green chemistry, neuro-engineering, health, environment

⁴⁶ Year established as part of an ETH Domain institution; some of the external sites had been established before being part of an ETH Domain institution (e.g. Eawag Kastanienbaum)

Institution	Main site: City, canton	External sites: City, canton(s)	Estab- lished ⁴⁶	Main focus of external sites
PSI	Villigen, Canton of Aargau	Single-site institution		
WSL	Birmensdorf, Canton of Zurich	Institute for Snow and Aval- anche Research SLF, Davos, Canton of Graubünden	1989	High-altitude research, e.g. on snow and ice, natural hazards (mainly avalanches) and mountain eco systems.
		WSL Cadenazzo, Cadenazzo, Canton of Ticino	1991	Research on typical phenomena on the southern side of the Alps (e.g. invasive species in a warmer climate) Extension to Italian-speaking practitioners.
		WSL Lausanne, Lausanne, Canton of Vaud	1991	Research on typical phenomena in the western part of Switzerland (e.g. agroforestry, pâturages boisés) Extension to French-speaking practitioners.
		WSL Sion, Sion, Canton of Valais	1995	Operation of experimental sites in the Valais, extension on snow and avalanches in the Canton of Valais
Empa	Three main campuses: – Dübendorf, Canton of Zurich – St. Gallen, Canton of St. Gallen – Thun, Canton of Bern	Sion, Canton of Valais	2014	In Sion the Laboratory of Materials for Renewable Energy, jointly operated by Empa and EPFL, develops novel energy storage systems, e.g. for hydrogen.
Eawag	Dübendorf	Kastanienbaum, Canton of Lucerne	1960	Center for Ecology, Evolution, and Biogeochemistry incorporating activities of three Eawag departments, Aquatic Ecology, Fish Ecology and Evolution, and Surface Waters – Research and Management.

B

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B

Conditions for the Successful Execution of the Basic Mandate

Introduction

As stipulated in the Federal Council's Strategic Objectives for the ETH Domain for the Period 2017–2020⁴⁷, the institutions of the ETH Domain aspire to the best possible quality in all their areas of research, in teaching, knowledge and technology transfer and in all other fields in which they are active. To continuously fulfil the ETH Domain's mandate in the Swiss context, favourable framework conditions from which the ETH Domain institutions and the Swiss higher education and research system benefit are of crucial importance.

The ETH Board confirms the three key success factors, i.e.

- internationality and openness;
- autonomy of the ETH Domain as a whole and of the ETH Domain institutions;
- stable and reliable funding by the Confederation;

and addresses them in Chapter B.1.

Supplementary important internal and external success factors are addressed in Chapter B.2.

⁴⁷ The Federal Council's Strategic Objectives for the ETH Domain for the Period 2017–2020
<http://www.ethrat.ch/en/eth-board/governance-eth-domain/eri-message-strategic-objectives>

B.1

Key Success Factors

Excerpt from the Mandate:

“The ETH Board has, in agreement with international findings and confirmed by the 2015 Intermediate Evaluation identified the following key factors for the future success of the ETH Domain: autonomy of the ETH Domain and its institutions, stable and reliable funding, international openness and networking. How are these factors to be assessed and how well are they ensured? What further internal and external factors are important?”

B.1 Key Success Factors

Assessment by the ETH Board

Assets

The ETH Board confirms the overarching importance of the three key success factors supplemented by further internal and external factors addressed in Chapter B.2.

a) Internationality and openness

- Switzerland's internationality and openness as a centre of education and research are a prerequisite for the ETH Domain to create benefit for the economy, society and the environment. Their excellent international positioning enables the ETH Domain institutions to attract excellent students, young academics, experienced researchers and professors as well as promising research projects, to participate in international research alliances, and to attract research departments of large international companies to Switzerland.
- Protecting internationality and academic openness is also a core requirement with regard to the ETH Domain's role and contributions towards large-scale research infrastructure. Free and non-bureaucratic access for researchers worldwide has applied in a reciprocal manner, also benefitting Swiss researchers at infrastructures abroad.

b) Autonomy

- The academic and financial autonomy of the ETH Domain and its institutions (dual autonomy) as granted by the ETH Act has been key to their successful development. Within this framework, the ETH Domain institutions currently benefit from freedom with regard to allocating their resources and the determination of their research priorities, which allow them to continuously and quickly adapt to the disruptive changes in science and technology. Thanks to their academic autonomy, the ETH Domain institutions are able to constantly shape and develop their curricula – including their offering in the area of continuing education – considering the trends set by cutting-edge science as well as the needs of industry and society.

c) Stable and reliable funding

- Stable and reliable funding from the Confederation is indispensable for the institutions to fulfil their basic mandate as well as for their future strategic development. In addition, several instruments have been developed – or are being more intensively used – by the institutions to further exploit current income sources, identify new sources, and seek to benefit from new collaboration and financing models for research projects and teaching.

Challenges

The ETH Board identified the following specific challenges:

a) Internationality and openness

- Acceptance of fundamental values of internationality and openness must not be taken for granted. The ETH Board and the ETH Domain institutions face the challenge to better demonstrate and communicate to the general public and to politics why upholding these values is essential for the ETH Domain's international competitiveness and for the quality of education and research it supports.

"The ETH Board has, in agreement with international findings and confirmed by the 2015 Intermediate Evaluation identified the following key factors for the future success of the ETH Domain: autonomy of the ETH Domain and its institutions, stable and reliable funding, international openness and networking. How are these factors to be assessed and how well are they ensured? What further internal and external factors are important?"

b) Autonomy

- The ETH Board is concerned about the tendency to increasingly regulate matters that jeopardise the dual autonomy of the ETH Domain and its institutions. The ETH Board and the institutions are challenged to counteract the apparent erosion of trust in the ETH Domain by creating transparency and ensuring accountability at all levels.
- Promoting mutual understanding on both sides (political and academic) requires a continued effort by the ETH Board to communicate academic values and needs, and to properly and promptly respond – with the help of the institutions – to political expectations regarding the degree of control over the ETH Domain by the owner and by parliament.

c) Stable and reliable funding

- Unforeseen budget cutbacks continue to pose a threat to the intermediate and long-term strategic planning and timely implementation of certain innovative activities or large-scale projects of the institutions and the ETH Domain (cf. Appendix B.1).
- The ETH Board would like to point out that diversified income sources – as they are also associated with challenges such as an incomplete coverage of overhead costs or limited flexibility of use – are essential but should only represent complementary funding. It must be borne in mind that all forms of third-party funding are highly volatile with regard to both predictability and the amounts actually provided.
- The massive investments of Asian countries into their universities and into selected research areas are a challenge for the international positioning and the successful competition of the academic institutions in Switzerland.

B.1.1 Internationality and Openness

Switzerland's internationality and openness as an education and research hub are a vital prerequisite for the ETH Domain to create benefit for society and the economy. The ETH Domain institutions use their excellent international position for the benefit of Switzerland, its economy, its public administration and private enterprises, its universities, and its educational system. This benefit derives primarily from the ETH Domain's standing and from its internationally embedded research and teaching activities.

Attractiveness: Global competition among higher education and research institutions entails competition for the best students, young academics, experienced researchers and promising research projects worldwide, but also for participation in research alliances, for promoting and deploying novel educational technologies and for attracting research activities of large international companies to Switzerland. The openness and the attractiveness of Switzerland and its economy must therefore receive the utmost attention, while the internationality of higher education and research must be strengthened as a central thrust of science policy.

Recruiting talents: The international embedding of the ETH Domain's activities makes it possible to attract world-leading scientists and talented students from around the world with whom both academic and economic actors can collaborate. They bring their knowledge and skills to the Swiss job market or act as ambassadors abroad as alumni of the ETH Domain institutions. As excellence attracts excellence, Switzerland as a location for science and business as well as the young Swiss academics themselves benefit from this approach (cf. Chapter A.2).

Teaching: The international reputation of Switzerland as hub for higher education and the diverse experience and backgrounds of scientists working in Switzerland form an excellent foundation for research-based teaching. In an educational environment characterised by internationality, Swiss students are effectively prepared for competition in business and industry as well as in academia in a global labour market. The increasing proportion of international students from bachelors to master's and then to the doctoral level ensure a stepwise exposure to the international environment (cf. Figure 14, Appendix A.2).

Research: International collaboration is crucial for the quality of science and research at the ETH Domain institutions. Working with scientists outside Switzerland provides access to valuable additional expertise. It also opens new ways of sharing costs, and makes it possible to tap into alternative funding sources (e.g. European funding). International collaboration in research projects is of growing importance, and scientific publications from international collaboration have been shown to achieve the greatest impact (cf. Chapter D). As a scientific location, Switzerland has always enjoyed a culture of openness and accessibility, enabling scientists from Switzerland, in turn, to gain research experience abroad, to compete in the international academic environment, and to participate in international networks (cf. Chapter A.1.2).

Large-scale research infrastructures: The conceptualisation, construction, operation and exploitation of large-scale research infrastructures are increasingly taking place in international networks. Their embedding in international networks allows the ETH Domain institutions to optimally profile their contributions and facilitates an efficient distribution of tasks among the international infrastructures, thus also enhancing their effective use. Switzerland as an academic and business location benefits from the ETH Domain institutions' close involvement in such networks, both in the development of scientific expertise and the promotion of innovation. Free and non-bureaucratic access for researchers worldwide based on competitive calls must continue to be granted – a principle which has always been applied in a reciprocal manner, benefitting Swiss researchers at infrastructures abroad as well. Therefore, most of the ETH Domain's large-scale research infrastructures are operated as user labs and are coordinated through the process of the Swiss Roadmap for Research Infrastructures (cf. Chapter A.1.3).

Science diplomacy: Benefits of internationalisation in science go beyond academia. International science collaboration also yields diplomatic benefits, helping to maintain good relations between countries even in the face of disagreements on other issues. International organisations such as CERN offer a powerful rationale for international scientific collaboration.

B.1.2 Autonomy

Autonomy is one of the core prerequisites for the successful positioning of the ETH Domain and its institutions for future challenges. A robust and well-balanced governance of the ETH Domain must therefore serve the objective of maintaining or extending the high degree of autonomy currently granted to the ETH Domain and its institutions. The fundamental value of autonomy emerges from the "dual autonomy" conferred by the Federal Act on the Federal Institutes of Technology (ETH Act)⁴⁸ upon the ETH Domain institutions and the ETH Domain as a whole. This "dual autonomy" is a cornerstone of the ETH Act and was a major achievement of the last revision of the Act in 2003. Such autonomy is central to the definition and timely implementation of new strategic initiatives, which will be even more relevant for the future of the ETH Domain and of Switzerland as an academic and economic focal point in Europe and worldwide.

⁴⁸ Federal Act on the Federal Institutes of Technology, of 4 October 1991 (as at 1 May 2017)

Autonomy of the ETH Domain

The ETH Domain enjoys the freedom to act within the framework of the ETH Act and the strategic objectives conferred upon the ETH Domain by the Federal Council. Strategic decisions that are of relevance for the ETH Domain as well as the ensuing allocation of the ETH Domain's global budget to the individual institutions, to strategic and other system-relevant initiatives or tasks are thus the responsibility of the ETH Board. This strategic role of the ETH Board ensures effective use of the federal budget allocated to the ETH Domain.

One particular challenge to the ETH Domain's autonomy concerns the implementation of the Higher Education Act (HEdA)⁴⁹. In this regard, the ETH Board must make sure that the autonomy of the ETH Domain is not restricted by the overarching coordination processes set out in the HEdA, even though the Domain remains under the auspices of the ETH Act (in relation to aspects such as governance, financial commitments and decision-making processes).

The ETH Board strives to maintain the autonomy of the institutions and of the ETH Domain. With regard to the autonomy of the individual institutions, the Board assumes a subsidiary role in that it supervises these institutions. This also entails defining and steering the associated processes and communicating them to the institutions on the one hand and to the Federal Government and Parliament on the other hand. In doing so, the ETH Board highlights the importance of properly balanced autonomy and accountability. In this respect, the current revision of the ETH Act seeks to specify the roles of the internal ETH Board members (Presidents of ETH Zurich and EPFL, representative of the research institutes and representative of the school assemblies) by excluding them from voting on a few specific topics and to recuse themselves on issues concerning their own institutions.

Academic and financial autonomy of the ETH Domain institutions

The autonomy granted to the institutions of the ETH Domain entails their freedom to explore novel and innovative scientific fields and to allocate their resources independently. Their capacity to act autonomously in a strategic and entrepreneurial spirit is a recognised strength of the ETH Domain institutions and must be preserved for the future. It allows them to invest heavily and primarily in fundamental, disruptive and long-term research as well as in thematic and applied research, which in turn makes them attractive for cooperation with the private sector.

⁴⁹ Federal Act on Funding and Coordination of the Swiss Higher Education Sector, of September 2011 (as at 1 January 2018)

B.1.3 Stable and Reliable Funding

Stable and reliable funding by the Confederation is indispensable to enable the institutions to play their key role in education, research and innovation (For information on the ETH Domain's funds see Appendix B.1). Thus the ETH Board considers it part of its mission to continue striving for political support to secure funding. Despite strong support from Parliament in the past debates concerning the four-year payment framework (*Zahlungsrahmen*), considerable unpredictability remains with regard to the ETH Domain's annual budgets, as these are not exempt from the budget cuts which the Confederation's may decide on as part of its austerity programmes (cf. Appendix B.1).

As the basic tasks of the ETH Domain institutions bind most of the resources, the institutions are forced to cancel or postpone investments in research infrastructure or selected research topics as a precautionary measure. Such measures primarily affect resources that the institutions need for exploring novel areas of potentially high strategic importance and thus particularly impact the institutions' strategic development. Hence, the ETH Domain institutions and the ETH Board see an increased need to adapt the legislation in such a way that the ETH Domain's budget can be "ring-fenced", i.e. exempted from budget cuts in future. Such protective measures are all the more necessary as from 2020 onwards the federal subsidies for the cantonal universities and universities of applied sciences will enjoy stronger protection⁵⁰ than the global budget of the ETH Domain. Otherwise, planning insecurity will continue to jeopardise the timely implementation of innovative activities or large-scale projects of the institutions and the ETH Domain.

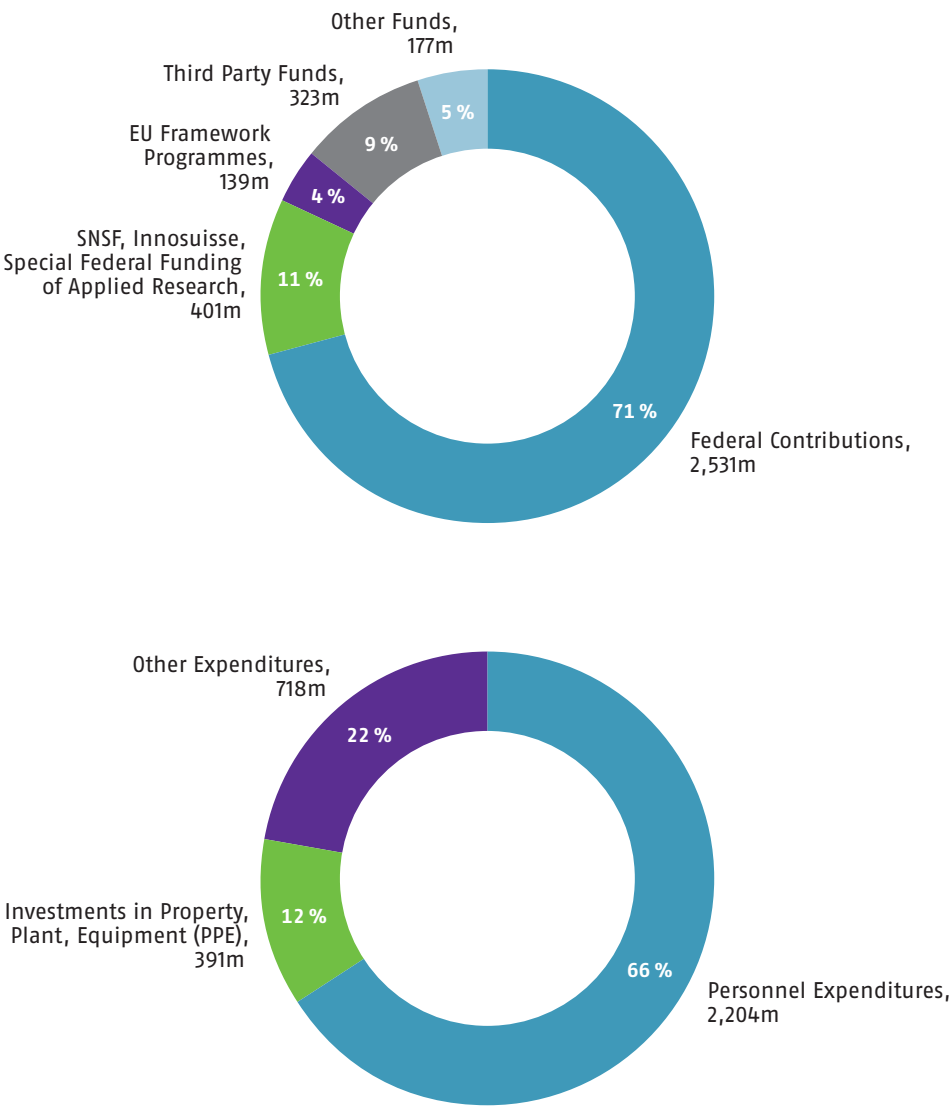
Given the poor prospects of any substantial increase in the federal budget for the ETH Domain in upcoming years (over and above fee increases), the diversification of income sources becomes more relevant for the ETH Domain, but needs to be optimised with regard to a number of competing aspects. This has been recognised in the past, and several instruments have been developed or made greater use of to further exploit current income sources, identify new sources and seek to benefit from new collaboration and financing models for research projects and teaching. These instruments include increased third-party funding from SNSF, EU, donations and cantonal contributions). However, the ETH Board would like to point out that diversified income sources should only represent complementary funding, as they are also associated with challenges such as an incomplete coverage of overhead costs or limited flexibility of use. It must be borne in mind that all forms of third-party funding are highly unpredictable, also with regard to the amounts actually received. Therefore, stable funding by the Confederation still provides a crucial and indispensable foundation.

⁵⁰ Owing to the entry into force of Art. 50 of the HEfA, which limits federal subsidies to 20 % of the reference costs for universities and 30 % for the universities of applied sciences, these subsidies now effectively constitute "ring-fenced expenditures" in the overall budgetary framework for education, research and innovation. Future budget cuts may thus affect the ETH Domain disproportionately.

Appendix B.1

Source and allocation of funds

Figure 19: Source and allocation of funds for the ETH Domain 2017 (in CHF million)⁵¹



⁵¹ Annual Report of the ETH Board on the ETH Domain 2017 (with adaptations)

Changes to the ETH Domain's annual budgets

Despite strong support from Parliament in the past debates concerning the four-year payment framework (Zahlungsrahmen), considerable unpredictability remains with regard to the stability of the ETH Domain's annual budgets as detailed here (as of June 2018).

On February 24, 2016 the Federal Parliament approved the Federal Council's Dispatch on the Promotion of Education, Research and Innovation (ERI Dispatch 2017–2020). This dispatch envisaged a payment framework for the ETH Domain of CHF 10,177.8m for the period 2017–2020. This amount was substantially lower than the funds originally requested by the ETH Board (CHF 11,005m), which included the financing of the strategic initiatives defined by the ETH Board. Therefore, the Federal Parliament, with Federal Decree 4 of 15 September 2016, increased the payment framework by CHF 160m. The Payment Framework for the years 2017–2020 then resulted in a total of CHF 10,337.8m for the ETH Domain.

Due to an expected slowdown in the economy, the Federal Council later reduced the Federal Budget 2018 and the Federal Financial Plan 2018–2020. These cutbacks implied a reduction of CHF 278.7m in the maximum disburseable portion of the ETH Domain's payment framework. Subsequently, this was partially offset by special items (CHF 46.6m) and by increased federal contributions (CHF 65.9m) granted by the Federal Parliament and the Federal Department of Economic Affairs, Education and Research. All these changes result in a maximum disburseable portion of only CHF 10,171.6m (as at June 2018), which is down CHF –166.2m or –2 % compared to the decreed Payment Framework for the period 2017–2020.

The past and potential future changes to the annual budget give rise to significant planning insecurity for the ETH Domain. This may affect explorative projects and initiatives at institution level that are vital to the development of larger strategic initiatives at the ETH Domain level.

B.2

Internal and External Success Factors

Excerpt from the Mandate:

“What internal and external factors do the experts consider to have contributed most to the successful national and international positioning of the two ETHs and the four research institutes?”

B.2 Internal and External Success Factors

Assessment by the ETH Board

Assets

In the ETH Board's perspective, the following internal and external factors have contributed most to the successful national and international positioning of the ETH Domain institutions in addition to the three key success factors addressed in Chapter B.1 (i.e. internationality, autonomy, stable and reliable funding):

a) Internal factors: ETH Domain level

- The combination of exact, natural and engineering sciences and their link to social sciences and humanities;
- The interdisciplinary research interfaces within the ETH Domain with their unique potential in terms of generating breakthroughs in research and finding uncommon solutions to urgent problems thanks to the combination of several disciplines;
- The internationally renowned research infrastructure of national importance designed, implemented and operated by the ETH Domain institutions;
- The complementary composition of the external members of the ETH Board – unifying personalities with varied educational, cultural and political backgrounds and professional experience at the national and international level.

b) Internal factors: Institutional level

- For the success of the institutions, the emphasis on leadership skills and the promotion of a leadership culture that is characterised by respect, responsibility, trust and support in combining work and family life, and assistance with employees' career development is of utmost importance.
- The adherence to the institutions' principle of excellence in all their activities, their international benchmarking and their willingness to strive for the highest quality at all levels of their activities (cf. Chapter A.1).
- Excellent students as well as excellent employees at all levels (incl. administrative and technical staff);
- The fostering of the entrepreneurial spirit throughout the ETH Domain (cf. Chapter A.2);
- The enabling culture at the institutions, offering a high level of freedom to staff at all levels to collaborate with academic partners or with industry within and outside the ETH Domain;
- Adequate base funding of professorships at ETH Zurich and EPFL as well as for research groups at the research institutes that provides freedom to explore innovative new or high-risk approaches (cf. Chapter B.1).

c) External factors

- The freedom of teaching and research as guaranteed in the Federal Constitution;
- A high quality of life within Switzerland, the political stability, the well maintained public infrastructure;
- The quality of the Swiss dual education system as well as the availability of skilled personnel;

“What internal and external factors do the experts consider to have contributed most to the successful national and international positioning of the two ETHs and the four research institutes?”

- The general support for research and higher education by society and the reasonable degree of regulation of specific research areas (e.g. research involving humans or animals, genetic engineering or stem cell research), providing clear procedures and tasks for researchers as well as for the respective authorities, thus enhancing legal certainty;
- In general, the renunciation or only cautious use of top-down implemented research programmes by the federal government enables researchers to focus on long-term fundamental research.
- The positive perception and embedding of the institutions of ETH Domain within the Swiss population, especially at the regional level (cf. Chapter A.5).

Challenges

Besides the necessity to secure the key success factors for any sustainable and successful positioning of the ETH Domain – i.e. openness and internationality, dual autonomy, and stable and reliable federal funding –, strengthening the ETH Domain institutions' position within the overall academic and economic system in Switzerland has to meet a number of major challenges at both the structural and the thematic level:

a) Internal factors: ETH Domain level

- Sustaining the current level of political experience and competence within the ETH Board for maintaining successful communication with the Federal Parliament, political parties and cantonal authorities will be a challenge.

b) Internal factors: Institutional level

- A unique asset of the ETH Domain is that it not only provides an excellent environment for attracting the best researchers worldwide but also hosts world-leading user labs around large-scale research infrastructures. These serve the national and international scientific community as well as industry and are key for the further development of the innovation ecosystem in Switzerland. Strengthening this unique asset therefore means increasing its capacity to contribute to economic development as well as reinforcing existing and new high-tech industries in Switzerland.
- The promotion and implementation of the desired leadership culture at the institutions of the ETH Domain with its diversity of the employees is challenging.

c) External factors

- Challenges (incl. communication) related to the support for research by the Swiss society and a reasonable regulation of specific research areas (e.g. research involving humans, animal experimentation, genetic engineering or stem cell research);
- Top-down implemented thematically oriented research programmes by the government should be kept within bounds.

B.2.1 Internal Success Factors

The unique features of the ETH Domain

The ETH Domain is characterised by unique features, allowing an excellent positioning of all six institutions that maintain distinct profiles. The unique features of the ETH Domain are thus important internal success factors:

- The combination of exact, natural and engineering sciences and their link to social sciences and humanities: The ETH Domain is the only actor in Switzerland offering such a range of specialisation with the corresponding research and teaching activities. The resulting interdisciplinary network of competencies is key for the ETH Domain's capacity to provide solutions – in its areas of research – to the complex societal, political and economic challenges of our time.
- The complementarity of ETH Zurich, EPFL and the research institutes: The complementary character of the ETH Domain institutions and their areas of specialisation yields powerful internal synergies, which are vital to the ETH Domain's strong current and future position. While ETH Zurich and EPFL are engaged in teaching based on the world-class (and mostly fundamental) research they perform, as well as in intensive knowledge and technology transfer activities, the four research institutes – PSI, WSL, Empa and Eawag – specialise in world-class fundamental research and more applied research in their focal areas, and in technology development. Together, the six institutions cover the entire value chain from basic research and teaching to applications of new knowledge.
- The internationally renowned research infrastructures of national importance designed, built and operated by the ETH Domain institutions: The portfolio of the major research facilities in the ETH Domain is of utmost importance to the innovative, solution-related advancement of cutting-edge research. Many of its state-of-the-art large-scale research infrastructures are operated as user labs, allowing researchers from Switzerland and abroad to use these unique infrastructures, which the Confederation makes accessible through the ETH Domain institutions.

Leadership culture and management

The basis for creating an inspirational working environment in the ETH Domain is founded on a policy which is informed by respect, appreciation, equal opportunities, dialogue and trust and whose transparent, reliable structures and attractive employment and working conditions are designed to motivate employees to maximise their performance as they progress. The ETH Board and the institutions of the ETH Domain ensure working conditions and personnel regulations that reflect current international standards for academic institutions. Management tools are in place to support supervisors in their capacity as role models and leaders.

Working in a dynamic academic environment is challenging, but rewarding. The employees are expected to have a high degree of flexibility, a willingness to embrace change processes, and the ability to communicate openly. A high level of commitment, an effective and efficient way of working, team spirit as well as integrity, respect and tolerance in dealings with employees and supervisors are further prerequisites for successful collaboration in an international multicultural environment.

The leadership culture and management of the ETH Domain are based on a participatory style and are shaped by the specific requirements of an academic environment: assignments are formulated in broad terms and are usually not plannable. This demands a great deal of personal responsibility, initiative and ability to set priorities. Showing one another respect and appreciation as well as cultivating mutual trust and transparency are absolute prerequisites for smooth and satisfactory working processes.

Supervisors need to demonstrate good leadership and management capabilities as well as repeated and critical self-reflection, tolerance and a willingness to engage in dialogue and transparent communication. It is incumbent on supervisors to recognise conflict situations early, identify the causes, seek a dialogue with the employees concerned and produce solutions. The employers undertake to seek professional, solution-oriented advice from specialists and take action against encroachments on employees' integrity.

The principles set out above and the regulatory framework⁵² apply to all ETH Domain institutions; they are complemented by the institutional regulations and guidelines, including procedures for conflict resolution.

Figure 20 presents a selection of important documents related to leadership culture, management (incl. training), code of conduct, etc. by institution. The internal documents which cannot be accessed on the institutional websites are available upon request.

Figure 20: Institutional guidelines relating to leadership culture and management (examples)

Institution	Documents / Training courses	weblink
ETH Zurich	Compliance Guide	https://rechtssammlung.sp.ethz.ch/Dokumente/133_en.pdf
	The Respect Code of Conduct	https://www.ethz.ch/content/dam/ethz/associates/campaigns-dam/respekt-dam/documents/Code_of_Conduct_Respect.pdf
	Leadership Training Programmes	https://www.ethz.ch/services/en/employment-and-work/leadership-and-development/human-resources-courses.html
EPFL	Compliance Guide	https://polylex.epfl.ch/files/content/sites/polylex/files/recueil_pdf/ENG/ComplianceGuideEPFL_EN.pdf
PSI	PSI-Führungsgrundsätze	
	Betriebliches Gesundheitsmanagement am PSI	
WSL	Directive Protection of Personal Rights	
	Code of Conduct – RESPECT	
Empa	Compliance Guide	
	Leadership Principles	
	Health and Leadership	
	Respect – Our Code of Conduct	
Eawag	Compliance Guide	
Four research institutes	CAS Leadership in Science Programme exclusively open to employees of the four research institutes at the University of Applied Sciences and Arts Northwestern Switzerland	https://www.fhnw.ch/de/weiterbildung/technik/cas-leadership-science#

⁵² Federal Act of 24 March 2000 on the Personnel of the Swiss Confederation (FPA) (as at 1 January 2018); framework ordinance to the FPA of 20 December 2000 (as at 1 October 2017); ETH Board Ordinance of 15 March 2001 on Personnel of the Federal Institutes of Technology (as at 1 January 2018)

Participation

Participation is an important element of the governance and of the employment policy of the Federal Institutes of Technology, regulated through the Federal Act on the Federal Institutes of Technology (ETH Act)⁵³ and – by analogy – for the research institutes of the ETH Domain. The following articles of the ETH Act specifically relate to participation: Members of the ETH Board (Art. 24); Conference of teaching staff comprising teaching staff representatives (Art. 30); Assemblies of ETH Zurich and EPFL with equal representation of all groups of members (Art. 31); participation rights of all groups of ETH Zurich and EPFL members with regard to issues relating to the teaching, research and planning within the federal institute of technology (Art. 32). The implementation and the procedures related to the participation are defined by the ETH Board Ordinance⁵⁴ and the Research Institutions Ordinance⁵⁵ complemented by institutional regulations and guidelines.

⁵³ Federal Act on the Federal Institutes of Technology, of 4 October 1991 (as at 1 May 2017)

⁵⁴ Verordnung des ETH-Rates über die Eidgenössischen Technischen Hochschulen Zürich und Lausanne vom 13. November 2003 (as at 20 January 2004)

⁵⁵ Verordnung des ETH-Rates über die Forschungsanstalten des ETH-Bereichs vom 13. November 2003 (as at 1 January 2004)

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C

Strategic Focus Areas for Research 2017–2020

Introduction

To enable Switzerland to acquire the necessary know-how in pioneering fields of research that are increasingly relevant to society, the economy and the environment, and also to boost the country's competitiveness, the ETH Board has identified strategic focus areas (SFAs) for targeted funding. These address key societal challenges and boost strategic areas of research in the ETH Domain's portfolio. To this end, existing expertise in the ETH Domain is pooled and new initiatives across the institutions are supported in a coordinated manner.

Strategic Planning Process Related to the SFAs

The bottom-up approach for strategic initiatives (cf. Chapter A.3) is an efficient coordination procedure within the ETH Domain. The ETH Domain institutions propose SFAs based on their research competencies and priorities. These proposed SFAs undergo a stepwise review and evaluation process before the ETH Board decides about their inclusion in the strategic planning of the ETH Board for the ETH Domain.

For the period 2017–2020, the ETH Board defined the following SFAs: "Personalized Health and Related Technologies", "Data Science", "Advanced Manufacturing" and "Energy".

SFA Personalized Health and Related Technologies (PHRT): In health research, the natural and engineering sciences and their close cooperation with medicine have become indispensable for the continued development of personalised health and related technologies at the highest level.

SFA Data Science: The Data Science focus area is intended to reinforce Switzerland's competency in the field of exploiting huge data volumes, dealing with them safely and in an innovative manner to extract additional value from such data for different research fields.

SFA Advanced Manufacturing: In the Advanced Manufacturing focus area, novel production processes which substantially strengthen Switzerland's power of innovation and competitiveness are being developed together with industrial partners.

SFA Energy: In energy research, the ETH Domain is regarded as Switzerland's scientific centre of expertise. The activities in energy research launched between 2013 and 2016 within the scope of the Action Plan on "Coordinated Energy Research Switzerland" are extended since 2017 under the umbrella of the SFA Energy.

These SFAs tie in with and build on long-established fields of research and teaching at the ETH Domain institutions as well as on the established cooperation between institutions and with other universities, additional institutions of higher education and industrial partners. Several ETH Domain institutions are involved in each of the SFAs in various functions and with differing priorities in terms of content. The contributions they are making to these individual SFAs are outlined in Chapter C.1.

Implementation of the Action Plan on Digitalisation in the ETH Domain

In July 2017, the Federal Council presented the report “Herausforderungen der Digitalisierung für Bildung und Forschung in der Schweiz”⁵⁶ including the Action Plan on Digitalisation 2019–2020. The Action Plan on Digitalisation is intended to help society in dealing with the new chances, risks and challenges posed by digitalisation. Based on the inputs from the ETH Domain institutions, the Action Plan entails two measures to be implemented in 2019 and 2020 by the ETH Domain:

- To expand competencies at ETH Zurich and at EPFL by establishing additional new professorships in the area of computer science; and
- To establish a network of regional Advanced Manufacturing Technology Transfer Centers (AM-TTC).

The Federal Council has allocated an additional CHF 19m to the ETH Domain for the expansion of competencies at ETH Zurich and at EPFL. The ETH Board will invest CHF 10m from its strategic reserve for the AM-TTC pilot phase in 2019 and 2020. The Federal Council amended the strategic objectives 2017–2020 for the ETH Domain with the above-mentioned measures.

The leading role of the ETH Domain in digitalisation is described in Chapter C.2, and further information about the implementation of the Action Plan on Digitalisation is provided in the Appendix to Chapter C.2.

Financial Resources Allocated to the SFAs and Digitalisation

Figure 21: Funds allocated to the SFAs and Digitalisation

SFA 2017–2020	Allocated / earmarked funds (CHF m)
SFA Personalized Health and Related Technologies	50
SFA Data Science	30
SFA Advanced Manufacturing	20
SFA Energy	60 (prorated to the base budgets of the participating institutions)
Action Plan on Digitalisation 2019–2020	
Expansion of competencies at ETH Zurich and at EPFL (seven additional professorships)	19
Establishment of a network of regional Advanced Manufacturing Technology Transfer Centers (AM-TTC) (pilot phase)	10

⁵⁶ SBFI, Herausforderungen der Digitalisierung für die Bildung und Forschung in der Schweiz, July 2017

Outlook for SFAs and Digitalisation in the Strategic Planning Period 2021–2024

For 2021–2024, the three strategic focus areas, Personalized Health and Related Technologies, Data Science, and Advanced Manufacturing, initiated in the period 2017–2020, will be continued in order to realise their full potential.

SFA Energy: Energy research will continue to be pursued as part of the regular activities of the ETH Domain institutions in the period 2021–2024, though no longer under the umbrella of an SFA.

All SFAs incorporate central aspects of digitalisation. These too are (or will be) models of successful cooperation among the institutions within and outside the ETH Domain.

C.1

Relevance and Potential of the Strategic Focus Areas

Excerpt from the Mandate:

“The strategic focus areas in the ETH Domain for the period 2017–2020 are as follows: Data Science, Advanced Manufacturing, Personalised Health and Related Technologies and Energy. How should the potential of these focus areas be gauged in the context of the coordination of the entire Swiss higher education sector, international scientific trends and the needs of the Swiss economy and society, as well as their organisational and thematic implementation to date?”

C.1 Relevance and Potential of the Strategic Focus Areas

Assessment by the ETH Board

Assets

For the ETH Board, the strategic focus areas (SFAs) are excellent examples of coordination and collaboration within the ETH Domain, within the Swiss higher education sector and with industry in areas of high strategic relevance.

- All four SFAs bundle existing competencies within the ETH Domain and are fostering inter-institutional and interdisciplinary collaboration. They substantially accelerate capacity building at the institutions in areas of strategic importance.
- The SFAs are platforms for the interaction with industry, are fostering scientific community building and are providing students and doctoral students with special opportunities to perform their studies in highly relevant projects.
- The use of synergies between SFAs (e.g. SFA Personalized Health and Related Technologies PHRT and SFA Data Science) as well as coordination and task-sharing between the SFA PHRT and the Swiss Personalized Health Network (SPHN) lead to efficient and effective use of federal funding.

Challenges

- Strategic focus areas are long-term initiatives of the ETH Domain by their very nature. Stable and reliable funding is indispensable in order to create strategic focus areas and sustain them over more than one four-year period;
- In the national context, coordination with other networks is not always easy, e.g. due to discipline-related cultural differences in life sciences and in the medical field and due to the different governance of such networks.

"The strategic focus areas in the ETH Domain for the period 2017–2020 are as follows: Data Science, Advanced Manufacturing, Personalised Health and Related Technologies and Energy. How should the potential of these focus areas be gauged in the context of the coordination of the entire Swiss higher education sector, international scientific trends and the needs of the Swiss economy and society, as well as their organisational and thematic implementation to date?"

C.1.1 SFA Personalized Health and Related Technologies (PHRT)

<https://www.sfa-phrt.ch/>

Context and scientific rationale

Advances in the life sciences and in information technology allow the collection and analysis of large amounts of health-related data: clinical data, genomics and other “-omics” data, data from biobanks and health data gathered by individuals themselves (citizen data). Making use of such data for optimising the medical care of each individual, and not groups of patients per se, is the ultimate objective of personalised medicine (PM). While PM, sometimes also called “individualised medicine”, focuses on individual patients, “personalised health” (PH) aims also to use the data and their analysis for the benefit of the population at large, as it will become possible to identify and tackle health risks at early stages and to apply appropriate measures and strategies in response. Research into PM/PH is complex and internationally highly competitive, given its importance to society and its economic potential.

Making PH programmes possible requires a high level of innovative, interdisciplinary science and technology as well as sustained intensive collaboration between medicine and natural sciences, engineering and – most importantly – data science. In this realm, institutions of the ETH Domain are well positioned to make significant contributions, specifically through the development of new technologies which, for example, determine the precise molecular make-up of patients, the translation of innovative technologies into clinically relevant platforms or devices, the development and application of sensors that determine people’s phenotypic traits, and through training of clinical scientists and practitioners. However, there is only one entity within the ETH Domain with direct access to patients (Proton Therapy at PSI). Therefore, most PHRT projects necessarily include collaboration with principal clinical investigators from outside of the ETH Domain. In addition, PHRT complements the Swiss Personalized Health Network (SPHN)⁵⁷. SPHN is laying the foundations for research projects in this area such as a system for a nationwide exchange of health-related data. In combining and necessarily requiring the various disciplines mentioned above, PH reveals its outstanding position for harvesting the unique potential of the ETH Domain’s interdisciplinary setup.

What SFA Personalized Health and Related Technologies is about

The overarching goal of PHRT is to establish and drive forward the ETH Domain as a worldwide leader in individualised medicine: in essence, a person’s unique biological make-up will guide decisions on how to maintain and restore health.

The PHRT initiative is complementary to the efforts undertaken by other initiatives in Switzerland, such as the SPHN and the Swiss Data Science Center (SDSC) and is linked to international research efforts. These include “The Cancer Genome Atlas” (TCGA) and the “Cancer Moonshot” initiative (an MoU exists already), both at the National Institutes of Health (NIH, USA).

During the period 2017–2020 four programmes are being set up: an educational programme at the doctoral and postdoctoral level, translational technology projects, technology platforms, and personalized health research projects with direct relevance for the patient. Their goals are to (a) position the ETH Domain in the Swiss Personalized Health research and education environment, (b) provide research and technology results on a proof-of-concept level, (c) accelerate the translation of pioneering technologies from proof-of-principle to mature clinical deployment and (d) develop infrastructure platforms for clinical use.

⁵⁷ <https://www.sphn.ch/en.html>

Strategic relevance

Medicine and medical technologies are areas of great societal importance and have been selected as areas of high strategic priority for the ETH Domain. This is supported by the establishment of PHRT in the period of 2017–2020, but also by undergraduate training programmes in medicine, i.e. the new Bachelor's degree course in Human Medicine at ETH Zurich and the new "passerelle" of the Life Sciences and Engineering Bachelor's course at EPFL to the medical schools at the Universities of Lausanne and Geneva (cf. Chapter A.1.1). The strategic relevance will remain high and the interactions with clinical partners and hospitals will increase, building on the connections, programmes, technologies and platforms established in the first phase of the PHRT initiative. Some institutions of the ETH Domain also take part in the national SPHN initiative. Co-ordination of tasks, timelines and procedures is crucial. For example, ethical, legal and societal implications are discussed within the SPHN Ethical, Legal and Societal Issue (ELSI) advisory group, and data format standards in the SPHN data expert group. Representatives of the ETH Domain are members of all the respective committees and establish the mutual link. The consensus conclusions from these bodies are expected to be applied by the ETH Domain.

Advantages for science, society and the economy

PHRT aims to foster the development, implementation and translation of the technologies and the knowledge that will result in the realisation of the expectations raised by the concept of PH. Achievement of these goals will lead to a healthier society by helping citizens to improve their health, preventing the onset of disease, providing the precise molecular diagnosis of disease and the selection of the optimal drug or radiation-based "precision treatment" when disease occurs, or through behavioural changes. In addition to the direct benefits to the population's health, the programme will advance society through the development of new technologies and through knowledge that will form the basis for new economic activities, the generation of intellectual property and the definition of healthier lifestyles. Areas of economic opportunities include the fields of wellness, "theranostics", impact assessment, biosensors and other devices for personal and environmental monitoring and the digitalisation, storage and interpretation of health-related data. Furthermore, development of the relevant know-how, specifically in digitalisation, will help Switzerland to control its healthcare system.

Coordination within the Swiss higher education sector

Cooperation with institutions and programmes outside the ETH Domain is critically important for the future well-being of the population, given that with the exception of PSI no ETH institution has direct access to clinics and patients. Examples include:

- the PH Alliance Zurich – Basel, an innovative national Biobank programme;
- the Health 2030 initiative in the Lake Geneva region;
- the joint Center for Radiopharmaceutical Sciences of PSI, ETH Zurich and University Hospital Zurich;
- the Center for Personalized Medicine Research (CPMR) of ETH Zurich, the University of Zurich and the University Hospital of Zurich;
- the "Tumor Profiler Project" with F. Hoffmann–La Roche Ltd.

The ETH Domain contributes significantly to the Swiss higher education sector via its technology platforms. Close coordination of existing and future technology platforms, technology development programmes and research projects guides the investments within the ETH Domain and has an impact on the Swiss higher education sector. Examples are

- the Swiss Data Science Center (SDSC);
- D-HEST at ETH Zurich and the EPFL School of Life Sciences with their significant investments into state-of-the-art centres for the imaging sciences (ranging from atomic to molecular and organismal imaging);
- Radionuclide-generated methods (of great value for diagnostics), “-omics” data acquisition platforms, and computational BigData infrastructure;
- the Empa department “Materials meet Life”;
- the Center for Proton Therapy (incl. the new Gantry 3) at PSI;
- upgrades for protein crystallography at SLS (and further through upgrade to SLS 2.0);
- utilisation of the X-ray free electron laser SwissFEL at PSI;
- the establishment of an integrated structural biology centre and the new professorship in cryoEM tomography at ETH Zurich.

Current state of implementation

The PHRT initiative has been set up with a Strategic Committee (SC), an Executive Committee (EC), a Review Panel and an Office. A formal partnership agreement between ETH Zurich, EPFL, PSI and Empa was signed in December 2017.

The first call for proposals was published mid-June 2017. It was coordinated with SPHN, with the option of submitting joint proposals that would receive funding from both initiatives. All proposals were evaluated based on (a) external written reviews from international experts in the respective research field, and (b) two or three members of the PHRT Review Panel. Finally, the EC approved 27 projects out of the 48 submitted proposals: seven large interdisciplinary projects, 12 educational projects and 8 technology translation projects. Most of the projects were launched in the first half of 2018. The second call for proposals was published on 15 March 2018.

Furthermore, the EC initiated the installation of two Technology Platforms, one for Genomics (at Campus Biotech in Geneva) and one for Proteomics (at ETH Zurich). The PHRT platforms will focus on the analysis of clinical samples using standard operation procedures (SOPs). Collaboration with SPHN entities, in particular BioMedIT and the Data Coordination Center (DCC), are essential for the establishment and the operation of these platforms and has been formally set up between the respective programmes. The platforms are regularly monitored by a supervisory expert group. Both platforms have been operational since February 2018.

The PHRT programme is synergetic to the efforts undertaken by other initiatives within the ETH Domain, in particular SDSC. Therefore, the SDSC Executive Director is a member of the PHRT EC.

The obvious complementarity of SPHN and PHRT means that strategies and activities should be coordinated. The two calls were aligned in such a way that applicants can send their proposal to both initiatives and request complementary funding. On 23 March 2018, the two initiatives held the 1st Joint Personalized Health Day Switzerland, which was attended by more than 200 participants from the basic and clinical research, government, the press, industry and other interested sectors.

C.1.2 SFA Data Science

<https://datascience.ch/>

Context and scientific rationale

The convergence of smart, connected systems with breakthroughs in areas ranging from gene sequencing to nanotechnologies is driving the “Fourth Industrial Revolution”. In this new era, where data is the “new oil”, crude data is of little value. Nevertheless, if crude data can be extracted and refined, and eventually have an impact on decisions, its value will soar.

Data science sits at the intersection of several academic disciplines including data management and engineering, statistics, machine learning, algorithms, optimisation and visualisation. It offers a new tool to social sciences, economics, medicine, environmental sciences, and others, to understand and influence complex systems to make progress on some of the most arduous problems of our time.

The importance of data science and artificial intelligence (AI) technologies and their potential impact on countries’ economic and societal future is today widely recognized. To fully grasp the digitalisation opportunity, the majority of top-tier international research and teaching institutions, aligned with their governments’ strategy, are investing significantly in their own local dedicated centres and programmes. Centres linked to a single institution, often in competition with others from the same country, proliferate and fight for a leading position in our data-driven world.

What SFA Data Science is about

The ETH Domain’s SFA Data Science has given rise to the funding of the Swiss Data Science Center (SDSC). The Center’s mission is to accelerate the adoption of data science and machine learning techniques within the academic community at large as well as in industry.

While new AI methods are constantly being developed, acquiring and accessing data remains problematic and is one of the biggest challenges facing scientists. Moreover, the existing and available data is fragmented, and most projects fail to overcome the organisational silos that divide the bodies that create data from those that develop data analytics and systems and those that could potentially extract value from the data.

Thanks to its unique structure, the SDSC – jointly initiated and led by EPFL and ETH Zurich and closely collaborating with the research institutes – brings together the expertise of leading researchers throughout the country. Collaboration and resources mutualisation are thus privileged and, by reaching out to the academic community and industry, the SDSC lays the foundations for a truly national centre that strives to be globally competitive. It is composed of a multi-disciplinary team of data and computer scientists plus experts in selected domains, with offices in Lausanne and Zurich. By breaking down disciplinary boundaries, the SDSC acts as a real interface and service layer for data science projects while addressing transverse security and privacy issues, ultimately enabling multidisciplinary collaborations. It offers end-to-end data science services to the academic community and industry in Switzerland and internationally, backed by laboratories of the ETH Domain – and, in the future, also further afield.

However, successful multidisciplinary collaborations also require effortless access to data and methods, as well as the opportunity to easily reuse published research data – and build on it. The lack of existing tools fully addressing these needs today not only slows down research but also complicates the sharing and communication of results.

To help tackle these challenges, the SDSC is developing RENKU, an open-source software platform designed to facilitate the exchange of data and knowledge between all the actors involved in data science collaborations, while enforcing their respective data management plans. The platform will ultimately create an international community to share data, tools, methods and information in a federated environment.

Advantages for science, society and the economy

The SFA Data Science fosters excellence in multidisciplinary research, thus enabling scientific breakthroughs with high societal impact. In particular, environmental sciences – well represented by the ETH Domain institutions – as well as personalised health, which is specifically part of the SDSC mandate, have the potential to nurture strong synergies between data providers, data and computer scientists and subject-matter experts for the benefit of all. For example, personalising healthcare by targeting the right treatments to the right patients at the right times has the potential to improve and save lives.

Industry is showing great interest in the SDSC. The latter's involvement in smart and data-driven manufacturing can help companies improve their digitalisation effort and their return on investment. Finally, Switzerland's image will benefit from the reputation of a national centre promoting cutting-edge research and attracting outstanding scientists, locally and from abroad.

Coordination within the Swiss higher education sector

The RENKU platform, designed to facilitate the exchange of data and knowledge, will foster multidisciplinary collaboration and coordination between all the actors involved in data science, ultimately creating an international community.

As part of its mandates to contribute to the education and dissemination of knowledge in data science, the SDSC participates in EPFL and ETH Zurich teaching programmes: it takes part in the Masters in Data Science in both schools, including the very well attended Deep Learning course at ETH Zurich. The SDSC is also involved in continuous education: in the DAS (Diploma of Advanced Studies) in Data Science at ETH Zurich (as of autumn 2018) and the joint CAS (Certificate of Advanced Studies) in Data Science and Management (as of June 2018) at EPFL and the University of Lausanne's Faculty of Business and Economics, where it is co-responsible for the academic direction of the course.

Current state of implementation

The SDSC has been operational since January 2017, with offices in both Lausanne (on the EPFL campus) and in Zurich at ETH Zurich. The set-up process at the SDSC is well on track, with the launch of the RENKU platform, a successful first call for Data Science projects, and the ongoing academic and industrial collaborations.

The team across the two offices is growing steadily in accordance with the approved hiring plan. As of July 2018, the team comprises 25.5 full time equivalents equally distributed between the two offices and is well balanced in terms of gender.

The first call for proposals, published in March 2017, resulted in 74 qualified proposals. After a careful selection, 8 projects started in autumn 2017 and 10 in spring 2018, and are funded for two years. Projects from all six ETH Domain institutions have been accepted covering the broad range of research fields: physics, biology (incl. medicine), environmental sciences, computer science, economics, and others.

Hosted on national infrastructures, RENKU is today available in its beta release version to researchers worldwide on the cloud (RENU Lab). During the initial phase, data, methods and publications generated by various academic projects (result of the calls for projects) are feeding the analytics platform. RENKU's adoption at the national and international levels, as well as by industry, will be a key metric of success. The resonance within the Swiss academic community has been excellent so far. Discussions have also been initiated at the global level.

On the industry collaboration side, the Research Agreement Template defining IP terms and conditions developed with the Technology Transfer Offices from EPFL and ETH Zurich was signed in September 2017. It has been used to define the terms of two early adopters, Bühler Group and Peugeot SA. Several other research agreements are currently being discussed.

The media echo is very good and, after a little over 18 months, the SDSC is already perceived as a national centre of expertise for data science. In 2017, there were over 70 media clippings nationwide (print, web and TV).

C.1.3 SFA Advanced Manufacturing (SFA-AM)

<https://www.sfa-am.ch/>

Context and scientific rationale

Industry is a key contributor to national wealth and prosperity, generating 28 % of Swiss GDP. It is a catalyst for progress and a driver for our future. The world of manufacturing is currently undergoing a rapid change due to increasing digitalisation, which is in turn driving radical innovations in how products are designed, manufactured and used. The new manufacturing technologies will have a higher flexibility, performance and efficiency. At the same time, they will often be more complex in the sense of integration depth or at least different or even disruptive to the manufacturing technologies that have been used in industry so far.

The international scientific and technical community is developing advanced manufacturing technologies using the potential of today's very powerful digital technologies. Swiss industry is challenged to keep pace with the changes – often described as the “Fourth Industrial Revolution” – and is striving for leadership in these novel technologies.

The development as well as the transfer and introduction of such new technologies into an industrial application is often challenging and requires competencies and expertise in many different fields. Therefore, various partners with complementary competencies from science and industry need to join forces and collaborate to enable technology innovations in advanced manufacturing. The institutions of the ETH Domain, in particular ETH Zurich, EPFL, PSI and Empa, are predestined to take a leading role in developing such novel technologies.

What SFA Advanced Manufacturing is about

The programme of the SFA-AM aims to enable Switzerland's scientific and technical community to contribute at the most advanced level to these developments. It seeks to motivate the institutions of the ETH Domain to team up, collaborate in exploratory research projects and build the knowledge and infrastructure to position Switzerland as a leader in this field.

Advanced manufacturing is a very broad technical field. The participating institutions defined five Technical Focus Areas (TFA) for which exploratory research projects and the build-up of infrastructure have been launched. These TFA are viewed as highly relevant to Switzerland's economy and are in line with the involved ETH Domain institutions' strategies for the future. The five TFA are:

- Precision Free Form Manufacturing (Initial Program)
- Printed Electronics (Initial Program)
- Sustainable Digital Manufacturing and Design (Initial Program)
- Sensing Technologies (Expansion Program)
- Intelligent Systems and Advanced Automation (Expansion Program)

The programme of the SFA-AM in the period 2017–2020 includes funds for research projects as well as for capacity build-up and technology platforms (CB & TP). Both areas will include translational activities and contribute to technology and knowledge transfer to Swiss industry.

Advantages for science, society and the economy

In Switzerland, the scientific and technical community is facing a lack of research funds in pre-competitive technology development. Similar to the BRIDGE⁵⁸ programme, but with a specific focus on manufacturing and on enabling larger collaborative projects, the SFA-AM programme specifically contributes to closing the gap between the funding schemes of the Swiss in-

⁵⁸ BRIDGE is a joint programme conducted by the Swiss National Science Foundation (SNSF) and Innosuisse. It offers new funding opportunities at the intersection of basic research and science-based innovation, thereby supplementing the funding activities of the two organisations. <http://bridge.ch/en/>

novation agency, Innosuisse, and SNSF funding schemes for advanced manufacturing. It enables the participating institutions of the ETH Domain to team up and to execute collaborative research projects together with further scientific and industrial partners.

New infrastructure and technology platforms will be made available to other partners in the Swiss scientific and technical community, including universities of applied sciences. These could furthermore contribute to the national network of regional technology transfer centres in the field of advanced manufacturing (AM-TTC) that is planned as part of the larger-scale national Action Plan on Digitalisation.

The SFA-AM programme benefits Swiss industry through pre-competitive technology development, and by giving access to the new technology and characterisation platforms for collaborative research activities. By way of technology transfer, SFA-AM will thereby help Swiss industry to maintain its capacity for the local production of high value-added goods and to retain its strength as an exporter of innovative production processes and machines.

Coordination within the Swiss higher education sector

The research activities, capacity building and technology platforms of the SFA-AM will raise young engineers' awareness of advanced manufacturing and motivate them to learn about this field and about associated aspects of materials science. The SFA-AM Steering Committee selected the research projects also based on the criterion of whether the projects will drive the education of engineers at the cutting edge of advanced manufacturing. The transfer of research results into the curriculum of engineers and scientists will help the ETH Domain to maintain its position of excellence and international reputation in engineering education and will additionally benefit Swiss industry as employers of these engineers to master the new challenges of the Fourth Industrial Revolution.

The interdisciplinary teams of the SFA-AM projects bring together researchers, engineers and technicians with different backgrounds who jointly develop new technologies. The collaboration in cross-functional teams will provide new innovation impulses across borders between science and industry and between different scientific disciplines. In addition to this intra-project information exchange and collaboration, the SFA-AM programme fosters and facilitates inter-project exchange and collaboration by organising workshops and seminars as well as community-building and networking events. At these events, experts in advanced manufacturing can discuss current trends and challenges and find new partners with complementary competences for future collaboration.

Furthermore, the SFA-AM works together with other Swiss initiatives in advanced manufacturing to coordinate activities and to join forces. One example is the collaboration with the SATW Research Alliance Advanced Manufacturing⁵⁹ and its Expert Group "Additive Manufacturing" to jointly organise a large community-building event in spring 2019.

Current state of implementation

Based on the decision of the ETH Board to grant CHF 10m to fund research projects in advanced manufacturing in 2016, the SFA-AM issued a first call for project proposals addressing key challenges in the three technical focus areas of the initial programme. In a two-step selection process and based on the evaluation of international reviewers, the Steering Committee of the SFA-AM selected the seven projects in spring 2017. They were launched in the second quarter of 2017.

In spring 2017, the ETH Board decided to expand the SFA-AM programme and granted an additional CHF 10m – CHF 6m for CB & TP and CHF 4m for research projects. All four institutions prepared plans describing how they propose to use the SFA-AM funds for CB & TP in the context of their larger strategic initiatives in advanced manufacturing. These plans were presented at the SC meeting in November 2017. The SC fully supports the proposed CB & TP measures covering

⁵⁹ SATW is the Swiss Academy of Engineering Sciences. More information about the SATW Research Alliance Advanced Manufacturing is available at <https://www.satw.ch/de/advanced-manufacturing/>

the wide range from enhanced activities at the “Materials and Processes” Platform (ETH Zurich) to investments in new 3D Digital Printing Platforms (EPFL and Empa) and to detector development and performance improvement for existing beamlines at the large accelerator research facilities of PSI.

In summer 2017, the SFA-AM issued a second call for project proposals addressing key challenges in the two additional technical focus areas of the expansion programme shown below. Following the same two-stage selection process as in the first call and based on the evaluation of international reviewers, the SC selected four further research projects. These four projects were launched in the first quarter of 2018.

Beyond the research projects and the activities to build-up capacity and technology platforms, the SFA-AM has already organised a launch event as well as two information and community-building events and has planned further events and outreach activities. Further information on the current state of implementation can be found in the 2017 annual report as well as on the website of the SFA-AM.

C.1.4 SFA Energy

Context and scientific rationale

The ETH Domain performs world-leading energy research in order to develop methodologies and technologies to address challenges of the Swiss Energy Strategy and beyond. Research questions are addressed in a multidisciplinary way which cannot be provided by industry. Within the scope of the Action Plan on “Coordinated Energy Research Switzerland”, the Swiss authorities allocated additional funding to Innosuisse, the SNSF and the ETH Domain for the period 2013–2016. The institutions of the ETH Domain have benefited both directly and indirectly. Thus, a total of CHF 60m of the funding scheduled for 2013–2016 was allocated to the coordinated extension of energy research in the ETH Domain. One-third of the funds went into developing competencies (new professorships, as well as developing and expanding research groups). Two-thirds went into research infrastructures in the field of energy. Furthermore, institutions of the ETH Domain were nominated as leading houses for seven of the eight Swiss Competence Centers for Energy Research (SCCER), which are financed by Innosuisse.

What SFA Energy is about

For the period 2017–2020, the ETH Board decided to group the extended activities in energy research within the ETH Domain under the umbrella of the SFA Energy and allocated a total of CHF 60m to the base budgets of the participating institutions. Appropriate areas of work comprise the likes of energy efficiency, smart networks and harvesting of energy from renewables (ETH Zurich, EPFL, Empa), chemicals and hydropower (EPFL, PSI, ETH Zurich), as well as catalysis and catalytic biomass conversion (PSI). ETH Zurich started a cross-departmental initiative for an integrated Energy Systems Modelling Platform (Nexus)⁶⁰. Furthermore, the “Energy System Integration Platform” (ESI)⁶¹ was set up on the PSI site in close collaboration with the Empa research and technology transfer platforms NEST (“Next Evolution in Sustainable Building Technologies”)⁶² and “move – Empa’s Future Mobility Demonstrator”⁶³ as well as the Smart Living Lab⁶⁴ (EPFL Fribourg). Under the umbrella of the *Energy Change Impact* Research Program, WSL and Eawag joined forces to investigate the environmental and societal impacts of the intended energy transition and, accordingly, the respective measures to mitigate the anticipated effects. Funding from the SCCER *Supply of Energy*, the NRPs “Energy Turnaround” and “Managing Energy Consumption” and other sources was complemented with internal funding to advance re-

⁶⁰ <http://www.esc.ethz.ch/research/research-projects/Nexus.html>

⁶¹ www.psi.ch/media/esi-platform

⁶² <https://www.empa.ch/web/nest>

⁶³ <https://www.empa.ch/web/move>

⁶⁴ <http://www.smartlivinglab.ch/>

search, e.g. in the field of bioenergy potential assessment, hydrological forecasts for hydropower production (both WSL) and the related risks of extended small-scale hydropower production – e.g. positioning and acceptance (both Eawag). The Research Program gave rise to the launch and management of the nationwide working group “Knowledge and Technology Transfer in Large Energy Research Programs”⁶⁵.

Advantages for science, society and the economy

SFA Energy aims to foster the development, implementation and translation of the technologies and the knowledge in order to support the realisation of the expectations raised by the Swiss Energy Strategy 2050. The strategy is addressing, beside other goals, the reduction of CO₂ emissions according to the Swiss COP21 implementation plan, the replacement of nuclear power by (new) renewable technologies, and focused measures to increase the energy efficiency of our energy system. In this context, the ETH Domain institutions play a major role in advancing science and technology to enable the transition to a new, renewable and sustainable energy system and thereby assist Swiss industry and society. Thanks to numerous *Research and Technology Transfer Platforms (RTTP's, see above)* the interaction between academia and industry is being continuously strengthened. New concepts are being developed in a joint effort and validated in a realistic scenario. This approach is fostering innovation and creating broad visibility, thus helping Swiss industry to achieve market acceptance for the solutions developed.

Coordination within the Swiss higher education sector

The coordination and cooperation within the Swiss higher education sector has been very successfully fostered by the implementation of the ETH Domain's various Competence Centers (e.g. CCEM, CCES) which cleared the way for the creation of the eight SCCERs open to all higher education and research institutions in Switzerland. This is completed by the Center for Photovoltaics at CSEM, which is supported by and works closely with EPFL. Since the implementation of the ETH Domain Competence Centers and the SCCERs, the networked approach to Energy Research has significantly reduced redundancy and improved complementarity in the development of new technologies in the Energy Research field involving the institutions of the ETH Domain, cantonal universities and universities of applied sciences. Without this network approach, the mentioned RTTPs and demonstrators could not have been successfully designed, constructed and implemented. This network approach is the basis of their successful current operation.

Current state of implementation

Within the SFA Energy, implementation of planned activities as well as of ETH Domain-based R&D has been very successful. At Empa and PSI, the RTTPs NEST, move, ehub and ESI Platform are fully operational and a network of more than 100 partners from industry and academia are using them in an open innovation approach for the development of low-carbon and highly efficient solutions for buildings, mobility, local energy management and energy storage. Along similar lines, EPFL successfully built and operates the Energypolis demonstrator for synthetic fuels (EPFL Valais-Wallis) as well as the Redox Flow Battery demonstrator in Martigny. In addition, EPFL developed the Smart Grid Campus as realistic-scale smart grid used to develop and experimentally validate distributed sensing and control methodologies of MW-class energy storage systems supporting the maximisation of renewables penetration into the power grids. Within PSI, Empa and ETH Zurich, new concepts for short-, mid- and long-term energy storage are being developed. Examples range from seasonal heat storage systems for buildings to new battery concepts using aqueous electrolytes or low-cost Li-ion battery analogues on the basis of sodium. Within cross-cutting activities at different institutions (PSI, Empa, ETH Zurich, EPFL), new and advanced “Power-to-Product” concepts for the specific needs of seasonal energy storage have been developed. Some of them are already transitioning to industrial-scale pro-

⁶⁵ <https://www.wsl.ch/en/about-wsl/programmes-and-initiatives/energy-change-impact/working-groups.html>

duction. Within these activities, manifold modelling activities on different scales are supporting experimental implementation at the level of the RTPs and of communities/cities in order to demonstrate the potential of the convergence of sectors (mobility, buildings, industries) and energy carriers (electricity, heat and cold, hydrogen, synthetic natural gas, feedstock, etc.).

To reach the current state of implementation, all institutions have among other things been funding new laboratories (some associated with new professorships), active in the key research domains of energy research. PSI implements the Swiss Center of Excellence for Nuclear Energy and Safety. EPFL with its Swiss Plasma Center and the TCV (Tokamak à Configuration Variable) owns one of the world's leading fusion research laboratories, where our understanding of the physics of plasmas and the development of fusion as an energy source are being advanced. In terms of technology transfer, several successful spin-off companies have been founded at the different institutions. The ETH Zurich Master's programme in Energy Science and Technology and the new Master's course in Integrated Building Systems are educating engineers and architects in the energy domain. In parallel, ETH Zurich, EPFL and PSI are successfully training engineers within their joint Master's programme in Nuclear Engineering.

C.2

Leading Role in Digitalisation

Excerpt from the Mandate:

“In view of the ongoing process of digitalisation, the institutions of the ETH Domain have a special role to play in terms of the early identification and adoption of related trends in science for Switzerland as a centre of knowledge and industry. What strategies are already in place in the ETH Domain to enable the institutions to play a leading and driving role for Switzerland? Do the prevailing framework conditions in the ETH Domain allow them to exercise this function?”

C.2 Leading Role in Digitalisation

Assessment by the ETH Board

Assets

The ETH Domain institutions are in an excellent position to play a leading and driving role in the digital transformation of Switzerland. Among the major factors contributing to this capability are:

- The ability of the institutions to identify trends in science and to autonomously create professorships and research groups in areas of high strategic importance to tackle current and future societal challenges;
- The ability of ETH Zurich and EPFL – in close cooperation with stakeholders from industry and public authorities to create new or reorient existing bachelor's, master's, and continuing education courses;
- Switzerland's leading international position in the core technologies of digitalisation, such as cryptography, blockchain, security and cybersecurity due to long-term investments in ICT as well as in computer science and related fields by the ETH Domain institutions many years before digitalisation became a societal challenge;
- The long-lasting dialogue and the collaboration with industry and the public sector in closely related fields of digitalisation;
- The implementation of the strategic focus areas (SFAs, cf. Chapter C.1) which, to varying degrees, are of relevance to digitalisation;
- The additional, specific federal funding for the expansion of competencies at ETH Zurich and EPFL in the context of the Federal Council's Action Plan on Digitalisation;
- The establishment of leading international companies in the field of digitalisation (e.g. Google, IBM, Logitech, Disney Research) in the proximity of ETH Zurich and EPFL.

Challenges

- Given the massive investments being made in digitalisation by large countries, Switzerland as a rather small country cannot compete with these countries at the same level.
- Switzerland's innovation capacity can be successfully fostered when funds are pooled and invested in institutions' existing expertise (technological leadership). However, there is a tendency (e.g. in the context of national research programmes) not to invest funds where the most impact can be generated but to politically distribute funds to different scientific disciplines or different types of universities.
- In the context of the international competition for the most talented people in the field of digitalisation, it is a huge challenge for the ETH Domain institutions to attract and retain the most talented people, as international high-tech enterprises can offer unreachable salaries.

"In view of the ongoing process of digitalisation, the institutions of the ETH Domain have a special role to play in terms of the early identification and adoption of related trends in science for Switzerland as a centre of knowledge and industry. What strategies are already in place in the ETH Domain to enable the institutions to play a leading and driving role for Switzerland? Do the prevailing framework conditions in the ETH Domain allow them to exercise this function?"

C.2.1 Digitalisation

Context

Digitalisation started seventy years ago when businesses began using computers. Over time, the tempo of digitalisation has increased steadily, punctuated by milestones such as personal computers, the internet and mobile and ubiquitous computing. The broad outline of the next stage of digitalisation is clear: sophisticated systems built on data science and machine-learning technology that bridge the physical and cyber worlds in new and diverse ways, with capabilities that were previously seen as exclusively human.

Previous waves of digitalisation disrupted commerce, finance, health, transport, mobility, agriculture, food, energy, and manufacturing – in fact every aspect of society. This next wave has the potential to change how we work and live, disrupt existing business models, create new economic sectors and strengthen institutions.

Switzerland and the digital transformation

This digital transformation is an opportunity for Switzerland to strengthen its general welfare and worldwide economic and reputational position by developing innovative new products and applications. At the same time, change of this magnitude can erode existing social and political structures, power constellations and legal and ethical standards. In a highly interconnected world, the global infrastructure faces many challenges and threats that are beyond the control of a single nation. Switzerland must take a leading role in this transformation, not the least because it will have far greater opportunities to assert Swiss values and priorities as a leader in the development and deployment of technology than as a consumer.

A key challenge in digitalisation is that technology has outrun and eroded existing trust models. The recent emergence of decentralised ledger systems (blockchains) raises the possibility that currencies, insurance, land registries and even voting might become decentralised, eliminating the need to trust centralised institutions and private entities. Switzerland has a leading international position in the core technologies such as cryptography, blockchain, security and cybersecurity due to long-term investments by the ETH Domain institutions.

Swiss prosperity was born in the industrial revolutions of the past. A major factor in our success was the foundation of world-leading institutes of technology, now combined in the ETH Domain. Switzerland needs to safeguard its future value-creation in a world in which traditional technology is increasingly complemented or even replaced by automated or cyber systems.

Appropriate measures are necessary in order to keep and even expand the traditional strength of the Swiss economy and society as digitalisation reshapes virtually all aspects of our society. Ambitious economies like China and Singapore have set the development of digital technologies as their priority, and they are investing massively in the expansion and quality of their academic institutions. Switzerland too should seize this opportunity and have the ambition to be a leader in developing and shaping the next stage of digitalisation of the economy and society.

The leading role of the ETH Domain in digitalisation

The institutions of the ETH Domain collectively not only have a long tradition of world-class research and teaching in the foundational areas of digitalisation but are also actively applying the technology to areas of societal interest. Individual efforts are complemented by major jointly taught courses as well as research and technology transfer activities.

For example, ETH Zurich and EPFL are leading the way in areas such as machine learning, data science, information theory, programming languages, software engineering, image processing, computer architecture, computer networking, computer graphics and security. At the same time, both institutions have successfully applied digitalisation to other sciences

through inter-disciplinary research in medical and health sciences, digital humanities, digital fabrication, robotics, energy science, environmental science and architecture. This process will continue as data-driven research, including novel simulation technologies, are infusing natural sciences with new models and methods.

The research institutes of the ETH Domain have invested heavily in digitalisation and are developing it further and applying it to important areas. Notable projects are the smart home testbed "NEST", which is jointly operated by Empa and Eawag and open to all institutions of the ETH Domain as well as to external partners; environmental monitoring using distributed sensor networks at Empa, Eawag and WSL; "mobility of the future" at Empa; the Energy System Integration (ESI) platform at PSI; and upgrades of large-scale ETH Domain research facilities at PSI such as Swiss Light Source (SLS 2.0) (cf. Chapter A.1.3).

The institutions of the ETH Domain are closely cooperating in joint and coordinated research and technology transfer activities in areas relevant to the digitalisation of society. They are mainly based on the National Centers of Competence in Research (NCCRs) funded by the Swiss National Science Foundation (SNSF), on the Swiss Centers of Competence in Energy Research (SC-CERs) by Innosuisse, and on the strategic focus areas (SFAs) of the ETH Domain.

ETH Zurich and EPFL have established security and risk competence centers such as the Zurich Information Security and Privacy Center (ZISC), the ETH Risk Center, the Center for Security Studies (CSS), the Center for Digital Trust (C4DT), and the EPFL International Risk Governance Center (IRGC), which are dedicated to basic research into and transfer of knowledge about digitalisation-related challenges for society, industry and the Swiss government. Members of ZISC, established at ETH Zurich in 2003, and faculty members at EPFL serve on advisory committees of Federal and Cantonal Offices. CSS at ETH Zurich, which links academia and political consultancy, has a major influence on Switzerland's national security and cybersecurity policies. The newly established C4DT at EPFL brings together stakeholders from research, innovation, society and policy to develop and deploy trust-building digital technologies, practices and regulations. Both institutions decided recently to increase their investments in areas that increase everyone's trust in technology, and in particular at the interface between distributed systems, security and cryptography. The initiative on verified software will address a fundamental cybersecurity challenge, since many attacks start with software defects. Verified software is also a way in which Switzerland can build on its reputation for quality and its engineering culture and move from being a consumer of software to a major producer of high value software products.

Finally, there are several NCCRs with major ETH Domain participation that foster collaborative research and attainment of critical mass in specific areas such as robotics, digital fabrication, computational design of novel materials and quantum science.

The institutions within the ETH Domain today work closely with society, government and industry on many aspects of the challenges that digitalisation poses for society. This collaboration involves all levels, including administration, scientific personnel, group leaders and professors.

Challenges for the ETH Domain

The institutions of the ETH Domain are well positioned internationally to support Switzerland's digital transformation. Their excellent reputations are reflected in the top positions in various university rankings. However, leading countries such as Singapore, China, South Korea, Taiwan and Germany have initiated massive investments in research and education in areas such as machine learning, cybersecurity and education. One factor that is slowing the digitalisation of research, education and transfer is the lack of critical mass. This observation not only holds for Switzerland in general but also for the ETH Domain, as set out in the SERI report⁶⁶.

⁶⁶ SBFI, Herausforderungen der Digitalisierung für die Bildung und Forschung in der Schweiz, Juli 2017

Switzerland faces two major challenges that exceed the scale of current efforts:

- digitalisation is reshaping virtually all aspects of our society; and
- ambitious and large economies have made the development of digital technologies their priority and are investing massively in the expansion and quality of their academic institutions.

Switzerland's scientific and innovative capabilities in the fields underpinning digitalisation and cyber technologies need to be increased through investments in joint efforts and in enhancing the capacity of the ETH Domain institutions.

Based on the analysis of the current situation in research, education and transfer to society, industry and government, the following four areas exhibit a substantial need for a joint effort and strategic support by the ETH Domain:

- Cyberphysical systems and the Internet of Things;
- Cybersecurity;
- Education;
- Digitalisation and society.

Some of these areas can be addressed in close collaboration of research institutions and industrial partners, for example in the areas of wireless technologies, Internet of Things, artificial intelligence, machine learning and high-volume data management. Owing in particular to their large-scale research infrastructures, the research institutions may provide a challenging test environment for new technologies and concepts in data processing and management that can later be used by industry.

Appendix C.2

Action Plan on Digitalisation in the ETH Domain

The two axes of the Action Plan on Digitalisation to be developed in the next two years comprise the following concrete measures:

Expanding digitalisation competencies at ETH Zurich and at EPFL

In the period 2017–2020, ETH Zurich and EPFL are establishing several new professorships in the area of computer science financed from the available institutional base budgets or third-party funds.

ETH Zurich and EPFL intend to address the additional efforts requested by the Action Plan Digitalisation and create seven additional professorships, four at ETH Zurich and three at EPFL. The proposed domains are

- Verified Software (2, ETH Zurich and EPFL),
- Education/Ethics/Policy in a Digital Age (EPFL),
- Computing in Health Sciences (2, ETH Zurich), Visual Computing (ETH Zurich),
- Trustworthy Digital Systems (EPFL).

Network of regional Advanced Manufacturing Technology Transfer Centers (AM-TTC)

Advanced manufacturing technologies that have been developed in pre-competitive research projects as well as new materials, processes or products whose feasibility have been proven by lab-scale prototypes and demonstrators must still take further steps and clear additional hurdles before they can be taken up by industrial companies. For these important steps towards a successful technology transfer, specific infrastructures as well as knowledge of how to operate such infrastructures are needed.

Today such technology transfer infrastructures often do not exist, either in research institutes or in industry, or else are not available to the scientific and technical community in Switzerland. This initiative therefore aims to close this gap in the innovation process between lab research and industrial application by establishing a network of regional Advanced Manufacturing Technology Transfer Centers (AM-TTC) in Switzerland. The Centers' overarching function is to increase the readiness level of lab-scale technologies for seamless take-up by industry.

Besides these very specific measures within the Action Plan on Digitalisation, the ETH Domain institutions have expanded their competencies and activities in digitalisation for many years and will continue to do so.

Digitalisation at ETH Zurich

ETH Zurich's efforts in the area of digital transformation started in 1948 with the foundation of the Institute of Applied Mathematics and today are making a substantial contribution to ensuring that both society as a whole and the business community are ready to grasp opportunities and challenges as they arise. ETH Zurich stands high in the university rankings (cf. Appendix A.1), achieving fourth place for computer science (THE). New methods of information processing are influencing research, teaching and technology development in all 16 department of ETH Zurich. ETH Zurich intends to expand the relevant core areas further over the next few years, especially in computer science and information technology.

Teaching

At ETH Zurich, the Department of Computer Science is playing a vital role in the digital transformation of teaching, research and technology transfer. The Departments of Information Technology and Electrical Engineering, Mechanical and Process Engineering (particularly Robotics), and Mathematics (particularly Statistics, as well as Computational Science and Engineering) are also making substantial contributions in this area. At the same time, digitalisation affects all study programmes, so computer science in general is now part of the curriculum and has its place in all courses of study at ETH Zurich. As part of the Critical Thinking Initiative, the “Science in Perspective” study programme of the Department of Humanities, Social and Political Sciences enables students at ETH Zurich to gain new, normative, historical and cultural perspectives on the content of their studies, including aspects of digitalisation. ETH Zurich also supports student initiatives that have the same objective, such as the “Robotics and Philosophy” project.

In addition to the 683 doctoral students, the established bachelor’s and master’s courses in Computer Science have nearly 1700 students enrolled on them, with another 1200 people studying for a degree in Electrical Engineering and Information Technology (figures for 2017). The Department of Computer Science also offers a summer programme for bachelor’s and master’s students (Student Summer Research Fellowships), thus enabling them to obtain research experience. ETH Zurich is active in “Teach the Teacher” – a professional development programme for teachers of computer science. Furthermore, in autumn 2018 ETH Zurich launched two continuing education programmes (CAS/DAS) in the area of cyber security. A master’s programme in cyber security will be launched jointly with EPFL in 2019.

Research

At present there are 60 active professorships in relevant core areas, of which seven have been created and 11 reoriented since 2013. Research in computer science/data science at ETH Zurich thus covers all aspects of the data value chain: generating and recording data, data organisation and storage, data processing, and learning from data (machine learning, deep learning, data mining). During 2018, other digital transformation projects which transcend the boundaries of the traditional disciplines have emerged from ETH+, the ETH-wide promotion and development programme: (1) Security and Privacy in the Digital Society. (2) RobotX, a new centre for intelligent machines, to strengthen ETH Zurich’s leading international position through the addition of a further robotics hub. (3) Digital Transformation & Society. (4) Center for the Foundations of Data Science, which brings together statistics, information theory and computer science so as to expand ETH Zurich’s leading role in fundamental research on machine learning.

ETH Zurich has set up numerous interdisciplinary centres in order to pool the available expertise and thus further strengthen teaching, cooperation with industry and research. These include:

- the Zurich Information Security and Privacy Center, with an Open Lab for working with industry (50 scientists);
- the Enterprise Computing Center;
- the Center for Learning Systems in collaboration with the Max Planck Society, with 29 professorships;
- “Disney Research Zurich”: the only Walt Disney Company research centre outside the USA, with over 100 researchers;
- the ETH Game Technology Center;
- as well as initiatives in the areas of blockchain, security and networks;
- ETH Zurich operates the Swiss National Supercomputing Centre (CSCS) (cf. Chapter A.1.3);
- Swiss Data Science Center (SDSC) (cf. Chapter C.1.2) (in collaboration with EPFL);

- the RiskLab combines research in mathematics and risk research with machine learning;
- the Health Ethics and Policy Lab explores the ethical dimensions of precision medicine and digital health;
- in the field of digital fabrication, ETH Zurich conducts research into the application of machine learning in construction and operates the NCCR for Digital Fabrication.

Knowledge and technology transfer

Zurich has developed into one of Europe's key centres for research and development in computer science, thanks to the presence of ETH Zurich, the University of Zurich and Zurich University Hospital, the research labs of several international corporations such as IBM, Google, Microsoft, Oracle and Disney, and the city's lively start-up scene. Since 2007, 221 ETH Zurich spin-offs have been founded on the basis of ETH Zurich research findings, mostly in the area of information and communication technology. They include Beekeeper (app for offline work, CHF 13 million venture capital), RoseReality (augmented reality/edtech), Wingtra (drone technology, 40 employees, founded 2016), Scailyte (artificial intelligence for single cell analysis, Mass Challenge winner 2018). Promoting knowledge transfer and interacting with society as a whole and with major stakeholders are key aims of ETH Zurich in the area of digital transformation. One example is the digital platform launched by ETH Zurich in 2018 as an interactive stage on which visitors can interactively experience the digital transformation and its impact on society. A further example is Scientifica 2017 (arranged by ETH Zurich jointly with the University of Zurich) on the theme "What data reveal", which attracted over 30,000 visitors. In addition, ETH Zurich contributes to the digital transformation in relation to a wide range of target groups, such as by hosting the Cyber Security Conference, participating in the Digital Day (which includes programming courses for school pupils) and the Digital Festival, and maintaining a strategic partnership with the World Web Forum, to mention just a few of its activities.

Digitalisation at EPFL

EPFL started preparing for the digital age back in the 1980s with the creation of a curriculum for computer science and a computer science department in 1981 and 1987, respectively. Since then, EPFL has invested heavily in the field of information technology and is today one of the main European centres for education and research in this area.

Teaching

EPFL's current study programmes in computer science, communications systems and electrical engineering are attracting an increasing number of students. In 2017, more than 2100 bachelor's, master's and doctoral students were enrolled in these programs. These students are highly sought after by the industry, finding a job within ten weeks after graduation on average. Indeed, many of them receive offers during their final semester. Recent EPFL initiatives to prepare students for the digital age include:

- Launch of the master's programme in Data Science in 2017 (153 students enrolled);
- Integration of computational thinking as a foundational course into all EPFL study programmes in 2018;
- In preparation: master's programme in Cybersecurity, offered jointly with ETH Zurich.

Since the launch of its first Massive Open Online Course (MOOC) in 2012, EPFL has built a strong reputation in e-learning (cf. Chapter A.1.1). In 2016, EPFL created the Extension School, which offers online courses and programmes to help professionals across functions develop the applied digital skills necessary for today's world. Four courses and programmes leading to a new type of academic qualification, a Certificate of Open Studies (COS), are already online. They do not

require participants to have any particular academic background or degree. Yet they are demanding enough to ensure that learners become highly specialised in cutting-edge fields sought out by industry. More than 200 learners have enrolled in them thus far and the retention and completion rates (> 80 %) are very high.

EPFL is also playing a key role in the digital transformation of the entire educational system in Switzerland. Since 2007, it has been the leading house of the “Dual-T” initiative funded by the SERI. This initiative aims to investigate how learning activities may be designed to close the gap between classroom instruction at vocational education and training schools and work-based training at companies.

EPFL also collaborates closely with primary schools across Switzerland in the context of the Thymio project. Thymio is a small educational robot developed at EPFL that allows children to learn the basic skills and knowledge of robotics and programming. To date, more than 1,500 teachers have attended courses where they learn how to use Thymio in their classes.

Research

In terms of research, EPFL has considerably invested in new professorships in areas related to digitalisation. Its School for Computer and Communication Sciences alone now has 50 faculty members (full, associate, assistant, adjunct professors), but faculty staff at other schools also work in digitalisation-related fields. Their excellent scientific achievements have been recognised in various ways:

- THE ranking: EPFL is ranked 10th in Computer Sciences and 14th in Engineering/IT;
- ERC grants rankings (all type of grants, period 2007–now): EPFL is ranked 2nd in PE7 Systems & Communication Engineering Panel) and 2nd (together with the University of Oxford and Technion) in PE6 (Computer Science & Informatics Panel);
- More than 25 EPFL scientists in computer science and electronics have an H-Index above 40.

Examples of EPFL's collaborative initiatives in digitalisation include:

- Swiss Data Science Center (SDSC), jointly with ETH Zurich: has a mission to accelerate the use of data science and machine-learning techniques within academic disciplines of the ETH Domain, the Swiss academic community at large, and the industrial sector (cf. Chapter C.1.2).
- Center for Digital Trust: a centre of excellence for IT security and personal data protection (<https://c4dt.org/>).
- Health 2030: a multicentric and multidisciplinary initiative aimed at exploring and exploiting the potential of new technologies in the fields of health and personalised medicine (<https://health2030.ch/>).
- Micro-Manufacturing Science and Engineering Center (M2C) with a focus on micro-manufacturing, high-precision 3D freeform material processing and high-integrity microstructures (<https://m2c.epfl.ch/>).
- Venice Time Machine project: a machine-learning project that analyses 1,000 years of records (maps, monographs, manuscripts and sheet music) in dynamic digital form (<https://vtm.epfl.ch/>).
- The SCALA language, invented at EPFL and supported by the EPFL Scala Center is used by millions of programmers around the world, with particular applications in big data, data science and financial applications (<https://scala.epfl.ch/>).

Knowledge and Technology Transfer

In terms of innovation, approximately one third of the spin-offs created by EPFL researchers and one third of the companies currently located at EPFL Innovation Park are in the area of information and communication technology (e.g. AXA Tech, Swisscom, Logitech, CISCO). Some companies even have an innovation cell fully dedicated to ICT (e.g. Firmenich's D-Lab, Swisscom Digital Lab).

This year, EPFL organised the first one-day conference on the topic "Digitization is my business" for small and medium enterprises (SMEs) interested in benefiting from opportunities offered by digitalisation. The event featured more than 14 thematic sessions and attracted more than 950 participants.

D

Bibliometric Analysis

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D

Bibliometric Analysis

D.1 Background and methodology

As set out in the Federal Council's strategic objectives for the ETH Domain (Appendix I), the ETH Board has commissioned a bibliometric analysis of the ETH Domain in view of the present intermediate evaluation. As in the previous cases and for the fourth time in a row, the analysis has been carried out by the Center for Science and Technology Studies (CWTS) at Leiden University, the Netherlands. This chapter summarises the main results of this study.

CWTS measured the bibliometric performance of the six institutions in the ETH Domain by analysing articles and reviews that were published between 2007 and 2016 and that are indexed in the Web of Science (WoS) database⁶⁷. Citations up to and including 2017 were taken into account. Similar to previous studies performed by CWTS for the ETH Domain (the latest in 2014), self-citations are excluded from the analysis and conference proceedings are not considered.

CWTS's methodology offers a variety of indicators aimed at measuring the scientific output of a particular institution as well as the impact of the publications it produces. In addition, CWTS assesses scientific cooperation patterns. Further details about the indicators referred to in this chapter are given in the information box "Indicators and methodology".

Different counting methods exist to take into account co-authorship. In this report, full counting indicates that all publications are counted once, regardless of the number of collaborating institutions. In fractional counting, by contrast, the number of collaborating institutions is taken into account in the calculation (if a publication is co-authored by two research organisations, or if one author has two affiliations, it is counted as half a publication for each organisation). One major limitation of the full counting approach is that publications co-authored by several institutions are counted multiple times, once for each institution. This creates a bias in favour of fields which tend to have a lot of co-authoring institutions on their publications. Furthermore, fractional counting seems to allow a better field-normalisation and to provide results that are more reliable⁶⁸. Fractional counting, on the other hand, gives less weight to collaborative publications, and specifically to "big" collaborative publications, which actually represents a large proportion of the publication activity of the ETH Domain's institutions. In the present bibliometric analysis, the institutions' global indicators PP (top 10 %) and MNCS were computed using the fractional counting method. This differs from previous bibliometric analyses of the ETH Domain by CWTS (last one in 2014), where the global MNCS and PP (top10 %) were calculated using full counting.

As indicated above, publication scores are normalised per field and publication year. For the present analysis, CWTS has used its own publication-based field classification for field normalisation. In concrete terms, this classification clusters publications into research areas based solely on citation relations⁶⁹. One important feature of this classification system is that it allows for a taxonomy of science that is more detailed, with more than 4,000 micro-field publication

⁶⁷ More precisely, the analysis focuses on publications in journals processed for the Web of Science's (WoS) database produced by Clarivate Analytics. The indexes used are the Science Citation Index (SCI), Social Science Citation Index (SSCI), and the Arts & Humanities Citation Index (A&HCI). The Conference Proceedings Citation Index-Science (CPCI-S) and Emerging Sources Citation Index (ESCI) databases within the WoS are not included in the study.

⁶⁸ Waltman, L., Calero-Medina, C., Kosten, J., Noyons, E.C.M., Tijssen, R.J.W., Van Eck, N.J., Van Leeuwen, T.N., Van Raan, A.F.J., Visser, M.S., & Wouters, P. (2012). The Leiden Ranking 2011/2012: Data collection, indicators, and interpretation. *Journal of the American Society for Information Science and Technology*, 63(12), 2419–2432
Waltman, L., & Van Eck, N.J. (2015). Field-normalized citation impact indicators and the choice of an appropriate counting method. *Journal of Informetrics*, 9(4), 872–894.

⁶⁹ Waltman, L., & Van Eck, N.J. (2012). A new methodology for constructing a publication-level classification system of science. *Journal of the American Society for Information Science and Technology*, 63(12), 2378–2392.

clusters, and better matches the current structure of scientific research. For previous bibliometric analyses of the ETH Domain, the 250 WoS journal subject categories were used for normalisation⁷⁰.

Because of these two important changes, the global MNCS values calculated with the new methodology (fractional counting and CWTS field normalisation) are lower than in previous analyses (see D.3 for a comparison). In some cases, the development of the global MNCS value over time is also strikingly influenced by the methodology (especially for PSI and WSL). This may be linked to the fraction of their publications that are highly collaborative or inherent to the fields in which these institutions are mostly active.

Indicators and methodology

The output of an institution corresponds to its total number of publications published during the 2007–2016 period within the reference database. Each publication is fully assigned to the institution, regardless of the number of authors and affiliations (full counting, see D.1).

Output is an important indicator to evaluate an institution's quantitative performance, but does not allow assessment of the scientific quality of the institution's contributions. This is the function of impact indicators, which are all based on the concept of counting the number of times publications are cited. In this chapter, we report on two impact indicators: the "Mean Normalised Citation Score (MNCS)" and the proportion of top 10 % publications, or PP (top 10 %). The normalised citation score corresponds to the number of times a publication is cited divided by the average number of citations for similar publications (in terms of field, publication year and document type). This allows for a valid comparison between scientific fields, which have all very different citation characteristics. The MNCS is obtained by averaging the normalised citation scores of the institution's publications. An MNCS score of 2 indicates that the institution's publications have been cited twice as often as on average. PP (top 10 %) corresponds to the proportion of publications that, compared with other publications in the same field and in the same year, belong to the top 10 % most frequently cited. A PP (top 10 %) of 20 % indicates that the institution has twice as many publications in the top 10 % (within their respective fields) than the average. MNCS is based on average citations and is sensitive to extremes, whereas PP (top 10 %) is not influenced by extremes but creates an arbitrary separation between what are considered "top publications" and the others. Thus, MNCS and PP (top 10 %) have opposite strengths and weaknesses and are used in combination for assessing the impact of an institution.

Scientific collaborations are also assessed in this chapter. Three types of collaboration, which are mutually exclusive, are identified: (i) "no collaboration" refers to publications authored by a single institution; (ii) "national collaboration" to publications that are produced by different institutions in Switzerland; and (iii) "international collaboration" to publications that are produced by institutions from different countries. If publications involve both national and international research organisations, they are classified as international collaboration. Analysing the collaborative nature of publications gives an indication of the extent to which the institution collaborates with others (what is the proportion of publications that are co-authored with other institutions?) but also a qualitative indication regarding these collaborations (do publications that are co-authored with other national or international institutions achieve better scores?).

⁷⁰ It should be noted that, even though normalisation is based on CWTS's own categorisation, the WoS journal subject categories are used for the visualisation of the institutions' research profile (see field categories in the first figure of each individual results of D.2).

D.2 Results

The individual results of the six institutions are presented in what follows. The most important aspects are represented in three figures for each institution⁷¹.

The first figure represents the research profile of each institution. It gives a general impression of the main fields involved in the research scope of the institution by showing the share of the output attributed to a particular research field as a percentage of the total number of publications (bar length and number next to the bar). A maximum of 25 research fields, each accounting for a minimum of 1 % share of the institution's total output, are included in the figure. The figure also shows the normalised impact of these fields (MNCS). The MNCS values are also represented in the bars by a 3-colour scale going from light to dark blue for low, average and high impact respectively, the worldwide average impact being defined as ranging from 0.8 to 1.2. The full research profiles of the six institutions can be consulted in the individual reports.

The second figure shows the trend of the two main impact indicators MNCS and PP (top 10 %) for the entire institution, and their development over time. The time scale represents seven publication periods of four years each, with citations accumulated up to and including the year after the end of each time block.

Finally, the third figure shows the output share as a percentage of the total number of publications (bar length and number next to the bar) and the impact (MNCS) of three collaboration typologies, namely: "international collaboration", "national collaboration", and "no collaboration". The MNCS values are also represented in the bars by a 3-colour scale (light to dark blue for low, average and high impact respectively).

⁷¹ For the calculation of the global MNCS and PP (top 10 %) values (second figure of each individual result), CWTs used the fractional counting method, as indicated in D.1. It is worth noting that this contrasts with the full counting method used for the indicators of scientific collaboration (third figures) and for the field-based MNCS values of the research profile (first figures).

D.2.1 Results for ETH Zurich

- Between 2007 and 2016, ETH Zurich has published 50,383 articles and reviews that are indexed in WoS. This means that researchers affiliated to ETH Zurich have produced around 5,038 WoS publications per year. This output has been cited 1,011,156 times, which on average is 20.07 citations per publication. CWTs's trend analysis shows that there is a pattern of increasing publication output and number of citations.
- The research profile of ETH Zurich (Figure 22) shows that the fields of physics, chemistry, environmental sciences and geosciences dominate the institution's research activities. Specifically, the most prevalent fields of activity for ETH Zurich are "Multidisciplinary Sciences" (MNCS=3.71), "Chemistry, Multidisciplinary" (MNCS=1.90), "Geochemistry & Geophysics" (MNCS=1.85), "Astronomy & Astrophysics" (MNCS=1.65) and "Physics, Condensed Matter" (MNCS=1.20). Each of these fields accounts for at least 3 % of ETH Zurich's publications over the period under review. The MNCS indicator is high in all these fields and is at least 20 % above the worldwide average. Other fields that each account for more than 1 % of ETH Zurich's total output but have a very high impact (MNCS>2.00) are "Physics, Multidisciplinary" (MNCS=2.45), "Physics, Particles & Fields" (MNCS=2.30), "Ecology" (MNCS=2.03), "Cell Biology" (MNCS=2.14) and "Biochemical Research Methods" (MNCS=2.24). Altogether, ETH Zurich has a high impact profile for all of its most prevalent fields of activity.
- The overall MNCS value for ETH Zurich is 1.56. This means that ETH Zurich's publications receive 56 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, 18 % of the output published by ETH Zurich is among the upper top 10 % of most frequently cited papers worldwide. In other words, ETH Zurich has 1.8 times more top publications than on average. The time evolution of the field-normalised citation scores (Figure 23) shows that ETH Zurich's MNCS and PP (top 10 %) indicators have remained high and stable over time. Specifically, the MNCS indicator values range from 1.52 to 1.55. Similarly, the proportion of publications in the top 10 % has remained above the 10 % threshold, with 18 % of ETH Zurich's publications belonging to the top 10 % of highly cited publications throughout all time periods.
- In terms of collaborations, 78 % of ETH Zurich's publications have been produced with some degree of collaboration (Figure 24). The publications produced in an international setting (63 %) have a higher MNCS value than publications produced in "national collaboration" and "no collaboration" settings. Publications resulting from international collaboration have an MNCS value of 1.95 and 21 % of these are among the top 10 % of highly cited publications in their corresponding field(s) and in the same year. Nevertheless, the impact of publications produced with a domestic partner and non-collaborative publications is also high, with an MNCS of 1.47 and 1.51, respectively, and a PP (top 10 %) value of 17 % for both.

Figure 22: ETH Zurich's research profile. The top 25 fields of activity are shown. Together, these fields account for approximately 56 % of ETH Zurich's output. The field-based MNCS values are computed using full counting.

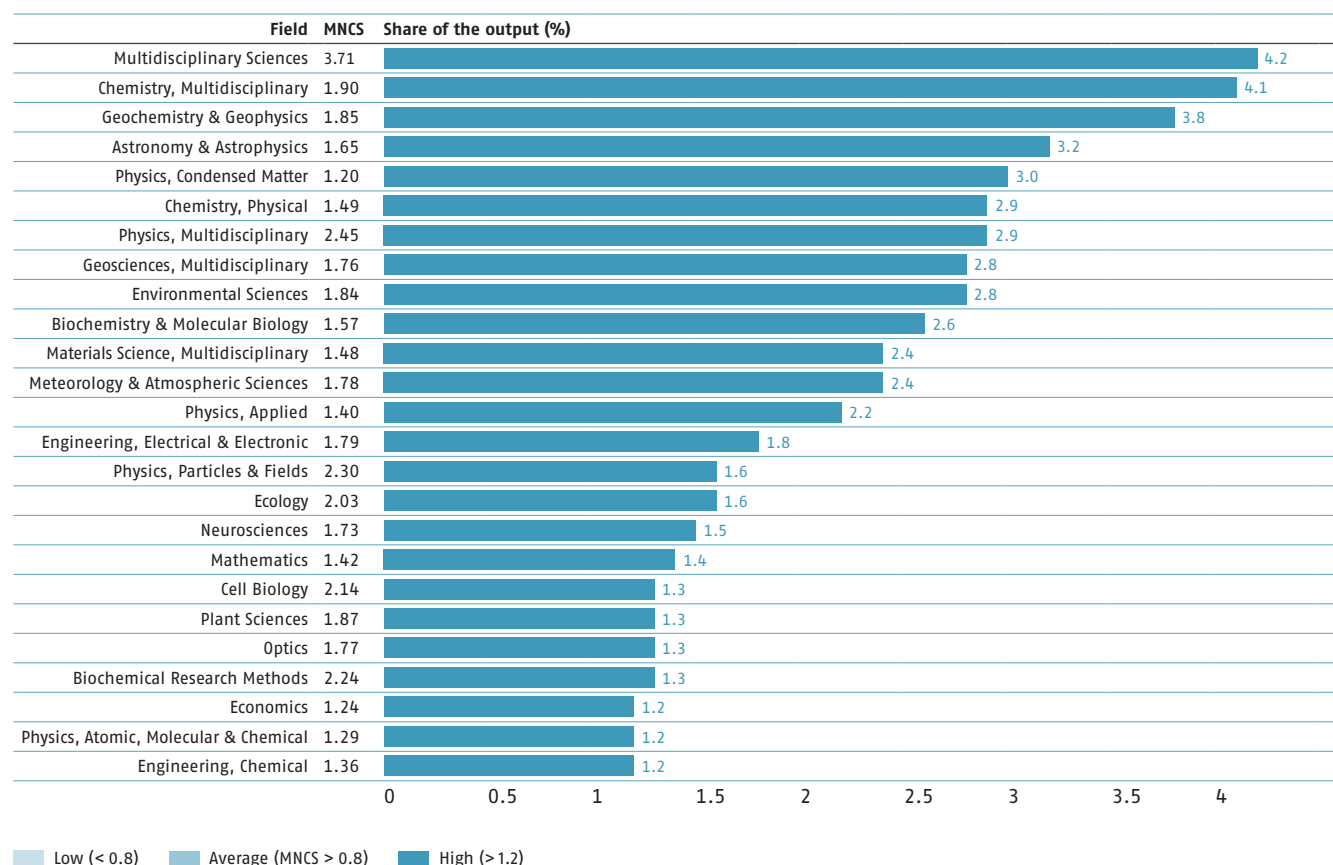
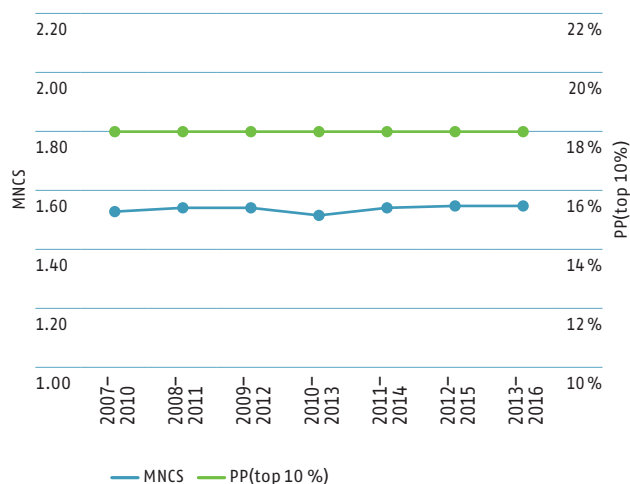
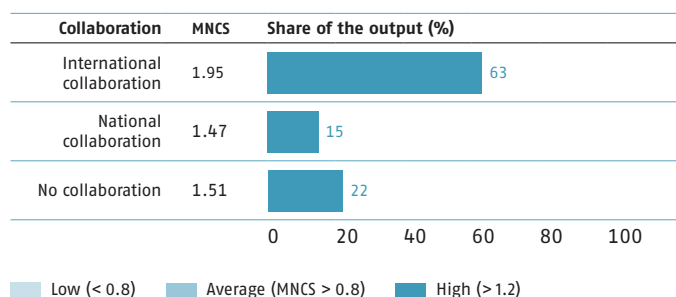


Figure 23: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for ETH Zurich.



Data analysis: CWTS, Leiden University; data source: Clarivate Analytics Web of Science core collection (applies to Figures 22-40)

Figure 24: Collaboration Analysis for ETH Zurich. The MNCS values are computed using full counting.



D.2.2 Results for EPFL

- Between 2007 and 2016, EPFL published 25,193 articles and reviews that are indexed in WoS. This means that researchers affiliated to EPFL have produced around 2,519 WoS publications per year. This output has been cited 594,826 times, which on average is 23.61 citations per publication. CWTS's trend analysis shows that there is a pattern of increasing publication output and number of citations.
- Figure 25 shows the main fields of activity of EPFL. The most prevalent fields for EPFL in terms of publication output are "Chemistry, Multidisciplinary" (MNCS=2.53), "Physics, Applied" (MNCS=1.58), "Engineering, Electrical & Electronic" (MNCS=1.46), "Physics, Condensed Matter" (MNCS=1.33) and "Materials Science, Multidisciplinary" (MNCS=1.83). Each of these fields represents at least 4 % of the total output of the institution. The impact of these publications is high, with all fields scoring an MNCS of at least 1.33 (i.e. 33 % higher than world average in their field). The field "Chemistry, Multidisciplinary" has an MNCS value of 2.53, which is considered very high. Other fields that account each for more than 1 % of EPFL's total output but have a very high impact (MNCS>2.00) are "Multidisciplinary Sciences (MNCS=3.73)", "Physics, Multidisciplinary (MNCS=2.74)", "Astronomy & Astrophysics (MNCS=2.96)", "Physics, Particles & Fields (MNCS=2.72)", "Biochemistry & Molecular Biology (2.01)" and "Cell Biology (MNCS=2.90)".
- The overall MNCS value for the whole institution is 1.63. This means that EPFL's publications receive 63 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, approximately 19 % of publications published by EPFL are among the upper top 10 % of highly cited papers worldwide. Figure 26 shows that EPFL's impact has remained high and stable over time. Specifically, the MNCS values range between 1.59 and 1.67. Additionally, the proportion of publications in the top 10 % has remained well above the 10 % threshold, with 18–19 % of publications belonging to the top 10 % of highly cited publications in all time periods. Similarly to the MNCS indicator, the PP (top 10 %) indicator values stay at the same level over time, which further confirms EPFL's high impact profile.
- In terms of collaboration, EPFL has published 77 % of its papers with some degree of collaboration, and 65 % of papers involved at least one international institution (Figure 27). EPFL's publications that have been produced in international collaboration have a very high impact (MNCS=2.27 and PP (top 10 %)=21 %). Single-institute publications also have a high impact (MNCS=1.80 and PP (top 10 %)=19 %). The publications with national collaboration have the lowest impact, though even this figure is above the world average (MNCS=1.42 and PP (top 10 %)=15 %).

Figure 25: EPFL's research profile. The top 22 fields of activity are shown. Together, these fields account for approximately 59 % of EPFL's output. The field-based MNCS values are computed using full counting.

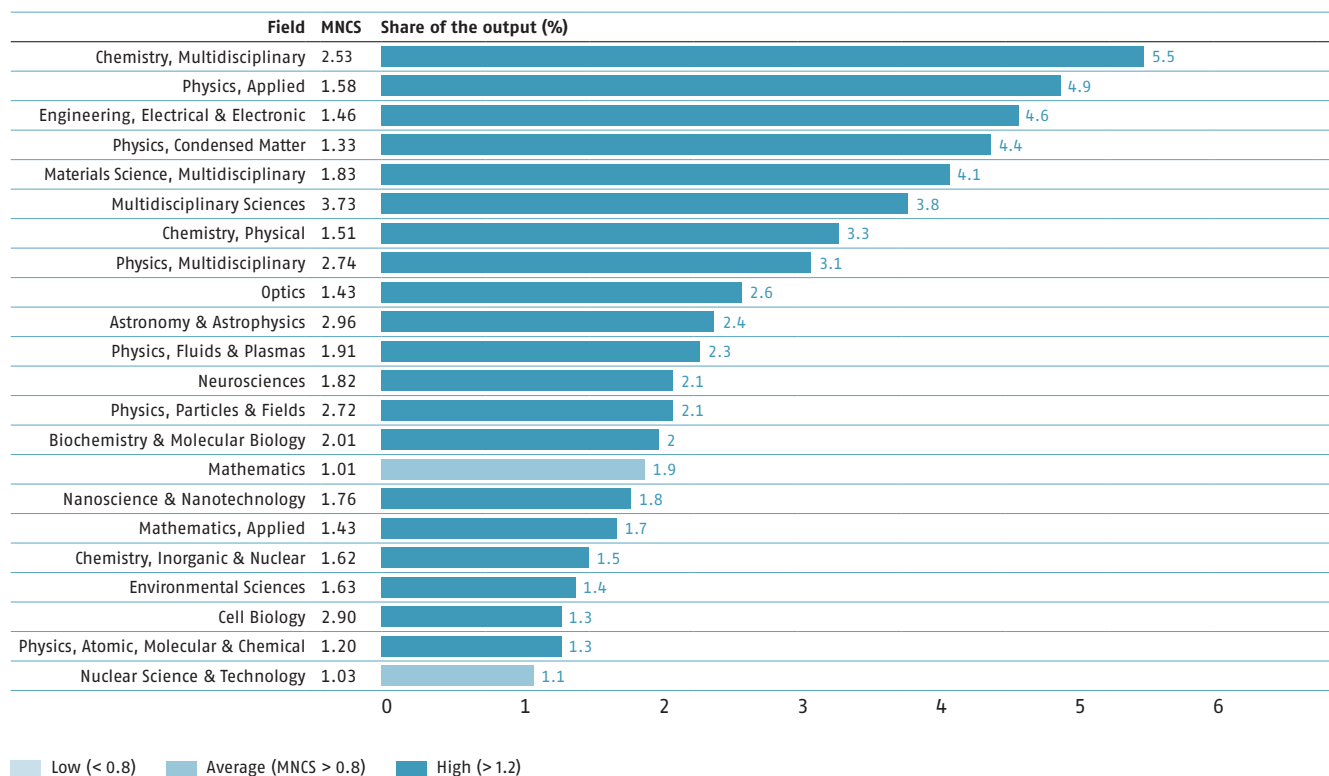


Figure 26: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for EPFL.

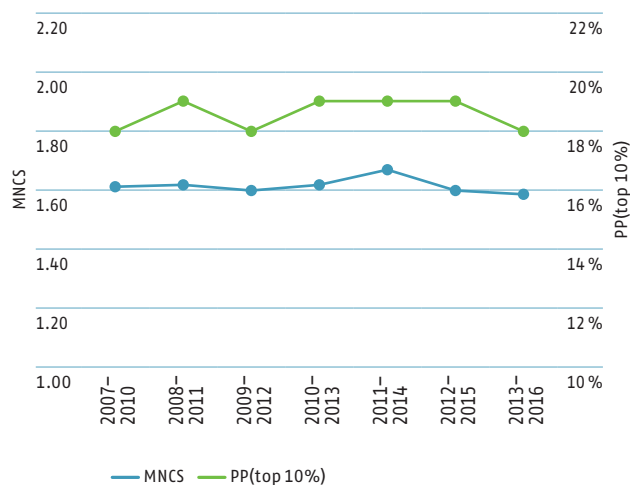
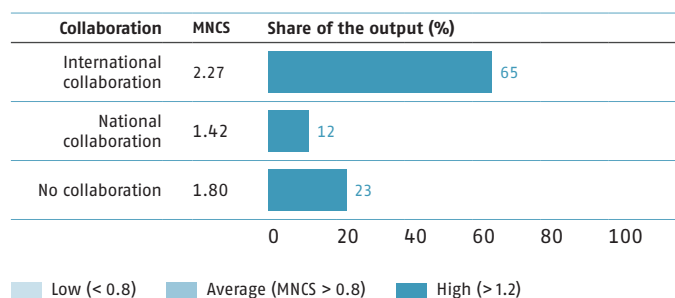


Figure 27: Collaboration Analysis for EPFL. The MNCS values are computed using full counting.



D.2.3 Results for PSI

- Between 2007 and 2016, PSI published 9,602 articles and reviews that are indexed in WoS. This means that researchers affiliated to PSI have produced around 960 WoS publications per year. This output has been cited 166,933 times, which on average is 17.39 times per publication. CWTS's report shows that the publication output and the total number of citations of PSI are increasing with time.
- The research profile of PSI (Figure 28) indicates that matter and materials, energy & environment and human health-related fields dominate PSI's research activity. Specifically, the most prevalent subject categories for PSI are "Physics, Condensed Matter" (MNCS=1.06), "Physics, Multidisciplinary" (MNCS=2.44), "Physics, Particles & Fields" (MNCS=2.08), "Nuclear Science & Technology" (MNCS=1.17), "Chemistry, Physical" (MNCS=1.18), and "Physics, Applied" (MNCS=1.41). In each of these top six fields, PSI published at least 5 % of its publications. These fields seem to reflect PSI's thematic orientation, goals and strategies and have had impact scores that are above world average (MNCS>1.00). Other prevalent fields that account for more than 1 % of PSI's research output, but have a very high impact (MNCS>2.00), are the fields of "Multidisciplinary Sciences" (MNCS=4.57), "Physics, Nuclear" (MNCS=2.23), and "Astronomy & Astrophysics" (MNCS=3.02).
- The overall MNCS value for PSI is 1.37. This means that PSI's publications receive 37 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, 15 % of the output published by PSI is among the upper top 10 % of most frequently cited papers worldwide. In other words, PSI has 1.5 times more top publications than expected based on the top 10 % threshold in their fields. The time evolution of the field-normalised citation scores (Figure 29) shows that PSI's impact has remained high and stable. Specifically, the MNCS value ranges between 1.23 and 1.46. This means that the MNCS indicator is above the worldwide average. Additionally, the proportion of publications in the top 10 % has remained above the 10 % threshold in the same field and year. Altogether, these impact indicators show slightly descending values until the period 2011–2014, recovering from there on. This contrasts with the results of the previous CWTS studies and is due to the methodology changes listed in D.1. More precisely, the change is caused by the fractional counting method being used in the new study for the calculation of the field-normalised impact indicators (i.e. giving less weight to collaborative publications). Typically, PSI, with its large research infrastructures and user laboratories, as well as by virtue of its mission and mandate, often publishes in collaboration with many other institutions. Indeed, between 2007 and 2016, 33 % of its publications were co-authored by more than five different institutions (17 % for ETH Zurich, 18 % for EPFL, 29 % for WSL, 13 % for Empa and 23 % for Eawag). Despite this decline, MNCS has remained high (>1.2) over time.
- In terms of collaboration, PSI has published 89 % of its papers with some degree of collaboration (Figure 30). 74 % have involved at least one international institution (the highest figure for all the six institutions). Over time, international collaboration is the type of partnership that results in publications with the highest impact (average MNCS of 1.71) and 17 % of these publications are among the top 10 % most cited in the world – a high figure. Publications resulting from "national collaboration" have exhibited a high impact level, but lower than that of papers produced in "international collaboration" (MNCS of 1.30 and PP (top 10 %) of 15 %). Finally, non-collaborative publications have shown an overall MNCS value of 1.22 and 12 % of these publications belong to the top 10 % of highly cited publications worldwide.

Figure 28: PSI's research profile. The top 24 fields of activity are shown. Together, these fields account for approximately 82 % of PSI's output. The field-based MNCS values are computed using full counting.

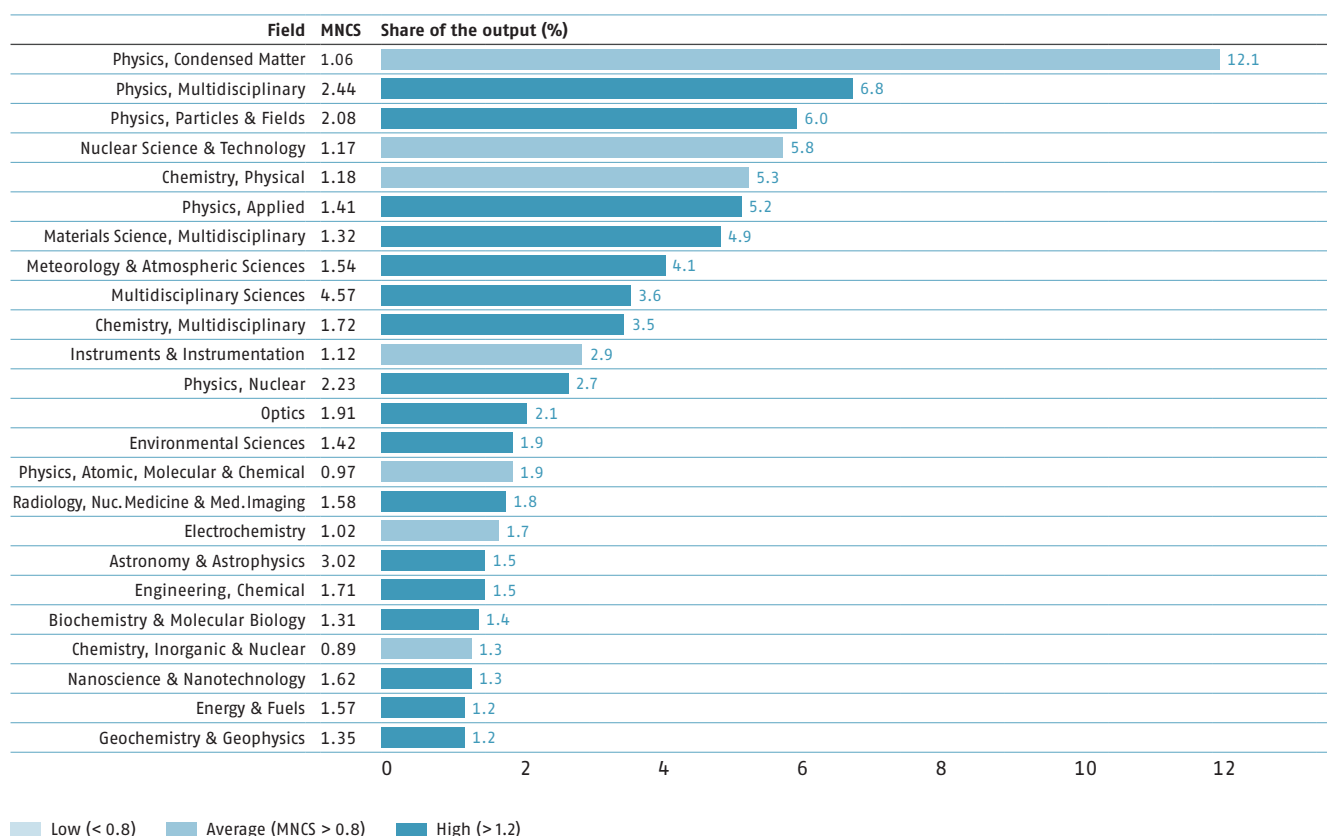


Figure 29: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for PSI.

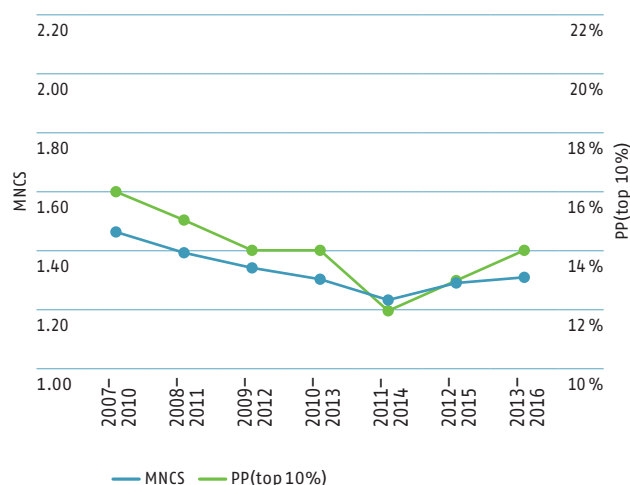
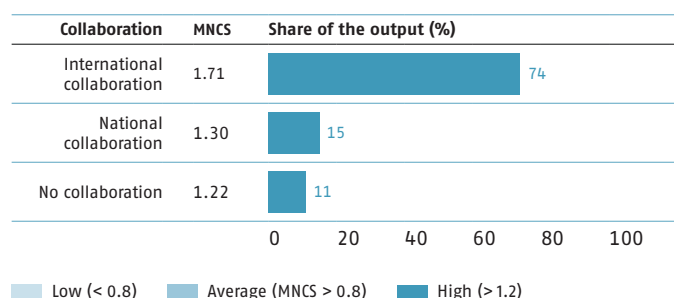


Figure 30: Collaboration Analysis for PSI.

The MNCS values are computed using full counting.



D.2.4 Results for WSL

- Between 2007 and 2016, WSL has published 3,047 articles and reviews that are indexed in WoS. This means that researchers affiliated to WSL have produced around 305 WoS publications per year. This output has been cited 62,670 times, which on average is 20.57 citations per publication. CWTS's trend analysis shows that there is a pattern of increasing publication output and number of citations.
- Figure 31 shows the main fields of activity for WSL. Specifically, it shows the share of publication output (%) and the impact (MNCS) separately per field of activity. The most prevalent fields of activity for WSL are "Ecology" (MNCS=2.00), "Forestry" (MNCS=1.57), "Geosciences, Multidisciplinary" (MNCS=1.71), "Environmental Sciences" (MNCS=1.73), "Plant Sciences" (MNCS=1.54), "Geography, Physical" (MNCS=1.59), and "Meteorology & Atmospheric Sciences" (MNCS=1.63). In each of these top fields, WSL publishes at least 5 % of its publications. The MNCS indicator in those fields is high – above 54 % of the worldwide average. Other fields that account for more than 1 % of WSL's research output but have a very high impact (MNCS>2.00) and at the same time a non-trivial amount of publications are "Multidisciplinary Sciences" (MNCS=3.78), "Biodiversity Conservation" (MNCS=2.23), "Geochemistry & Geophysics" (MNCS= 10.50), and "Evolutionary Biology" (MNCS=2.58).
- The overall MNCS value for WSL is 1.38. This means that WSL's publications receive 38 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, 16 % of publications published by WSL are among the upper top 10 % of most highly cited papers worldwide. In other words, WSL has 1.6 times more top publications than expected based on the top 10 % in their field(s). As can be seen from Figure 32, WSL's impact has remained high and fairly stable. Specifically, the MNCS values range between 1.37 and 1.44. This means that the MNCS indicator is well above the worldwide average. The MNCS indicator shows a slightly fluctuating pattern. Additionally, the proportion of publications in the top 10 % has remained above the 10 % threshold in the same field and year. The PP (top 10 %) indicator shows that WSL produced 16 % of top 10 % of highly cited publications in all time periods. To put it differently, WSL had 1.6 times as many top 10 % publications as the average for the same field and year. Finally, the fact that WSL's citation impact with the PP (top 10 %) indicator is higher than the average is in line with their high MNCS values. The values of WSL's impact indicators are affected by the change in the counting method introduced in the present study (from full counting to fractional counting, see D.3 for a comparison of the results of the previous period 2003–2012). This may be linked to the large fraction of WSL's publications that are highly collaborative (29 % of their publications were co-authored by more than five different institutions, the second highest fraction among all six institutions after PSI), while fractional counting gives less weight to collaborative publications.
- In terms of collaboration, WSL has published 88 % of its papers with some degree of collaboration, and 68 % of its papers involved at least one international institution (Figure 33). At the same time, WSL publications produced in an international setting have a much higher MNCS value as compared with "national collaboration" and "no collaboration". Specifically, publications derived from international collaboration have had an average MNCS value of 2.35 and 24 % of these publications are among the top 10 % of highly cited publications worldwide – the highest values for all six institutions. For comparison, the values of the MNCS and PP (top 10 %) indicators are 1.42 and 18 % respectively for the national collaborations, and 1.21 and 14 % respectively for the non-collaborative publications.

Figure 31: WSL's research profile. The top 17 fields of activity are shown. Together, these fields account for approximately 85 % of WSL's output. The field-based MNCS values are computed using full counting.

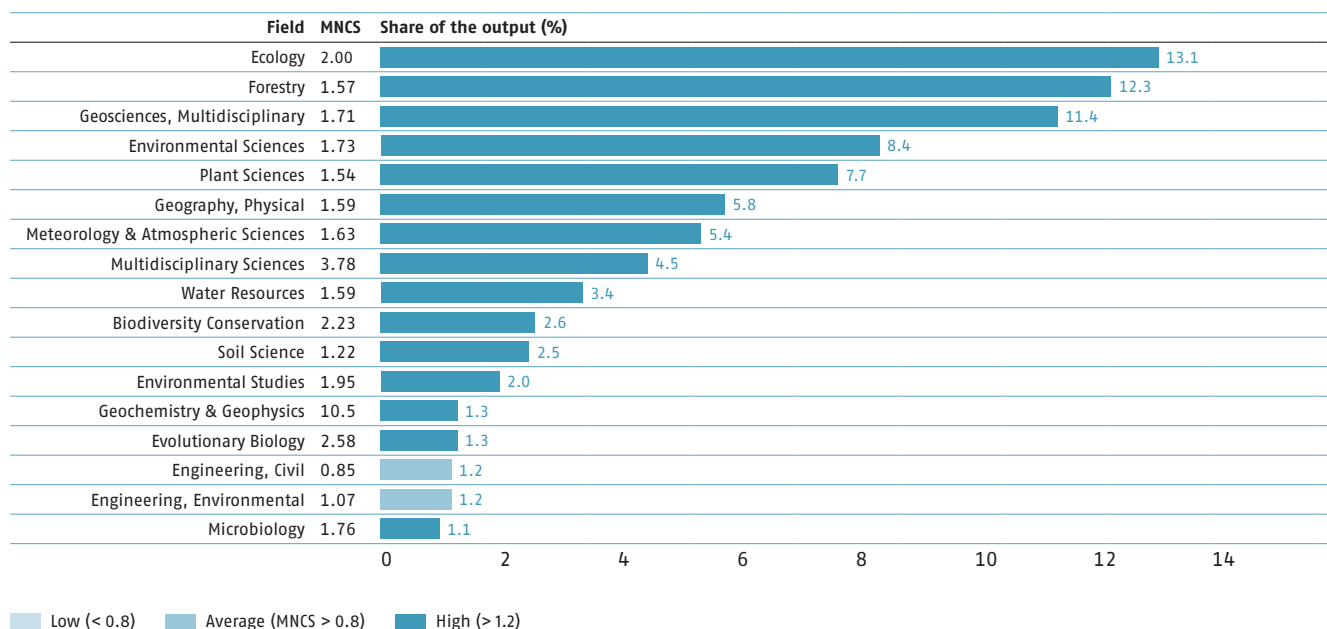


Figure 32: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for WSL.

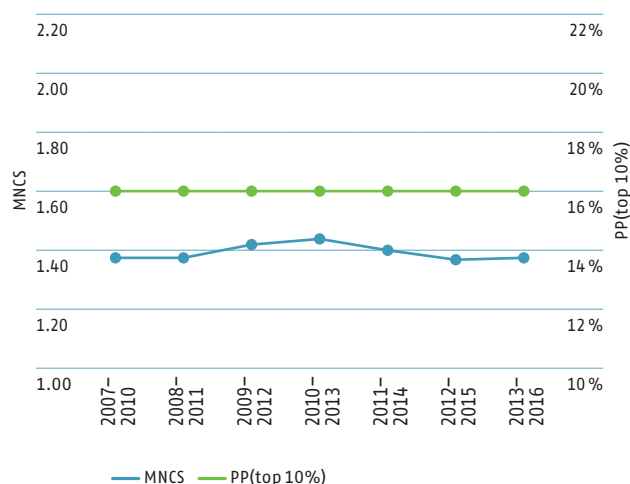
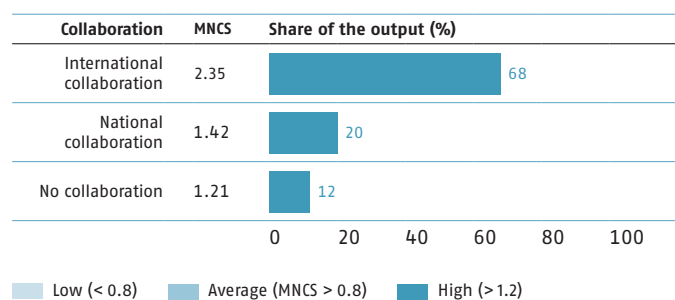


Figure 33: Collaboration Analysis for WSL. The MNCS values are computed using full counting.



D.2.5 Results for Empa

- Between 2007 and 2016, Empa published 4,988 articles and reviews that are indexed in WoS. This means that researchers affiliated to Empa have produced around 499 WoS publications per year. This output has been cited 90,083 times, which on average is 18.06 citations per publication. CWTS's trend analysis shows that there is a steady increase in publication output and number of citations received.
- According to the research profile of Empa (Figure 34), the most prevalent fields of activity in terms of share of output are "Materials Science, Multidisciplinary" (MNCS=1.52), "Physics, Applied" (MNCS=1.30), "Chemistry, Physical" (MNCS=1.52), "Chemistry, Multidisciplinary" (MNCS=1.98) and "Environmental Sciences" (MNCS=1.73), with at least a 5 % share of output. The impact of Empa's publications in their main fields of activity is generally high, with MNCS scores ranging from 30 % to 98 % above world average. Furthermore, other fields accounting for more than a 1 % share of the total output but with a very high impact (MNCS>2.00) are "Construction & Building Technology" (MNCS=2.23), "Energy & Fuels" (MNCS=2.20), and "Multidisciplinary Sciences" (MNCS=4.61).
- The MNCS value for the whole institution is 1.46. This means that Empa's publications receive 46 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, 17 % of publications are among the upper top 10 % of most highly cited papers worldwide. Thus Empa has 1.7 times more top publications than expected based on the 10 % threshold in the same fields and publication years. As can be seen from the time evolution shown in Figure 35, Empa's impact has remained high and stable with a slow increase in terms of the MNCS indicator. Specifically, MNCS increases from 1.41 in the first time block (2007–2010) to 1.53 in the 2011–2014 time block. In general, the values of this indicator remained high and above the world average. The PP (top 10 %) indicator has remained high and stable in all time blocks, with about 16–18 % of publications belonging to the top 10 % of highly cited papers worldwide. The fact that the PP (top 10 %) and the MNCS indicator scores are higher than on average in the same fields and publication years confirm that Empa has a high impact profile in the periods under review.
- Empa has published most (85 %) of their output with some degree of collaboration and more than half (59 %) of Empa's output has involved at least one international partner (Figure 36). Between 2007 and 2016, publications produced with at least one international partner have had an average MNCS value of 1.65. In addition, 16 % of these publications are among the top 10 % most cited of the world. Publications classified as "national collaboration" also exhibit high impact scores, with MNCS values of 1.61 and around 17 % of the publications classified as in the worldwide top 10 %. Similarly, non-collaborative publications show a high average impact, with an MNCS value of 1.48 and an average PP (top 10 %) of 17 %. The MNCS of publications produced without any institutional collaboration shows a rising trend in recent time blocks, and their impact is now comparable to (or even better than) the collaborative papers with international and national partners.

Figure 34: Empa's research profile. The top 24 fields of activity are shown. Together, these fields account for approximately 76 % of Empa's output. The field-based MNCS values are computed using full counting.

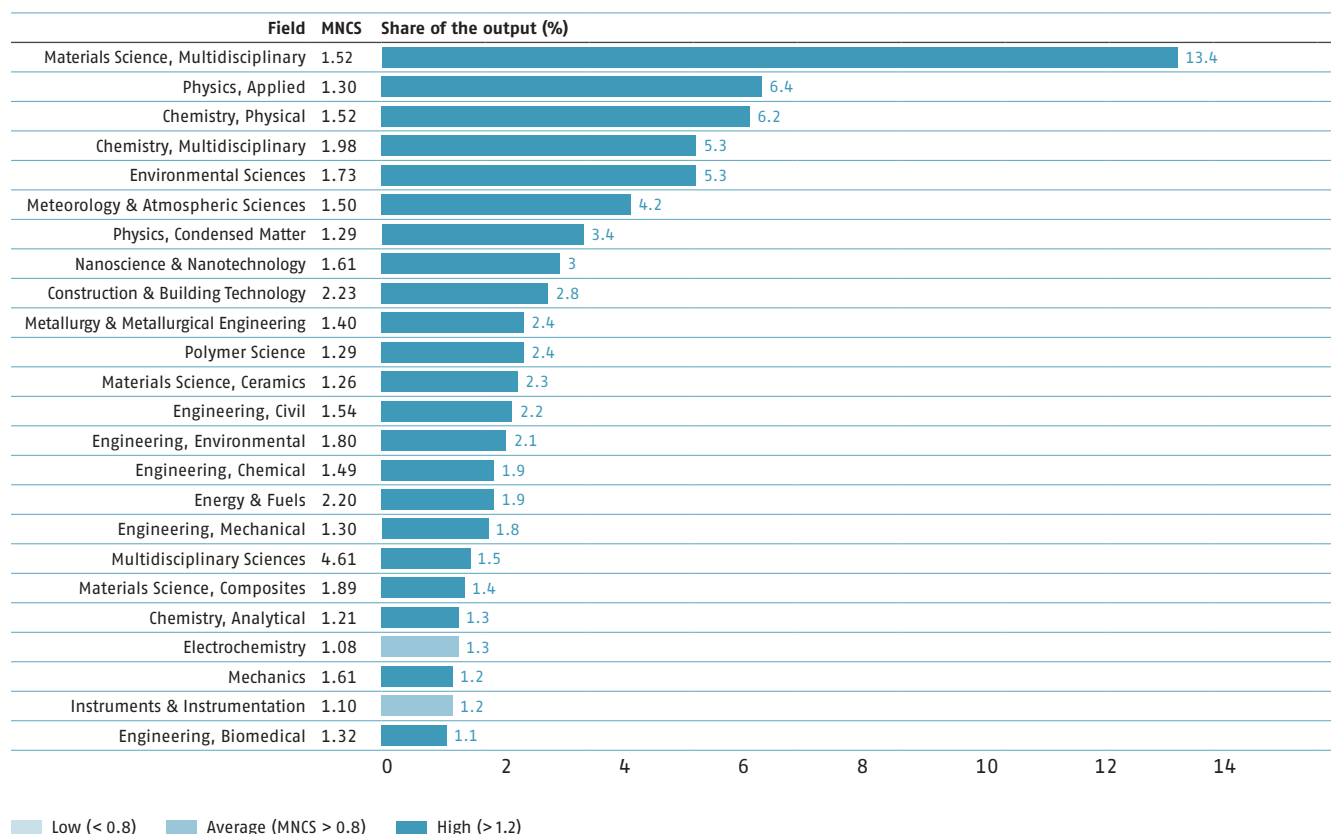


Figure 35: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for Empa.

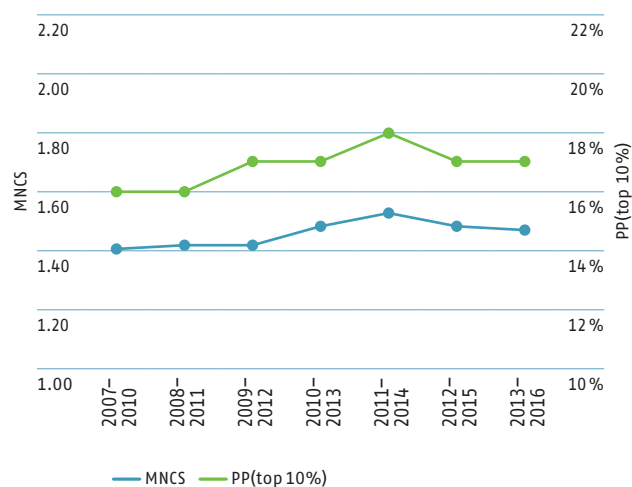
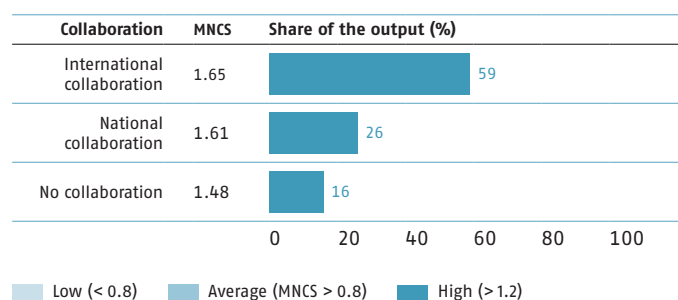


Figure 36: Collaboration Analysis for Empa. The MNCS values are computed using full counting.



D.2.6 Results for Eawag

- Between 2007 and 2016, Eawag has published 3,231 articles and reviews that are indexed in WoS. This means that researchers affiliated to Eawag have produced around 323 WoS publications per year. These publications were cited 72,383 times, which on average is 22.40 citations per publication. CWTS's report shows that both the cumulative numbers of publication and the total number of citations of Eawag have been increasing with time.
- The research profile of Eawag (Figure 37) indicates that the most prevalent fields for Eawag are "Environmental Sciences" (MNCS=1.74), "Engineering, Environmental" (MNCS=2.18), "Ecology" (MNCS=1.95) and "Water Resources" (MNCS=1.67). Each of these fields represents at least 5 % of Eawag's total output. The impact of Eawag's publications in these fields is generally high, with MNCS scores higher than 1.67 (i.e. 67 % higher than world average), and very high with MNCS scores higher than 2.00 (i.e. twice the world average). Furthermore, fields accounting for more than 1 % share of the total output but with a very high impact (MNCS>2.00) are "Geosciences, Multidisciplinary" (MNCS=2.01), "Multidisciplinary Sciences" (MNCS=4.05), "Microbiology" (MNCS=2.10), "Evolutionary Biology" (MNCS=2.00), "Genetics & Heredity" (MNCS=2.04), "Chemistry, Analytical" (MNCS=2.32), "Biochemistry & Molecular Biology" (MNCS=2.15), "Geography, Physical" (MNCS=2.23), and "Biology" (MNCS=2.46). Altogether, Eawag has a high impact profile for all of its most prevalent fields of activity.
- The MNCS value for the whole institution is 1.70. This means that Eawag's publications receive 70 % more citations than the average publication in the same field and year. In terms of the PP (top 10 %) indicator, approximately 21 % of publications published by Eawag are among the upper top 10 % of highly cited papers worldwide. This means that Eawag has 2.1 times more top publications than expected by the top 10 % threshold in the same fields. Eawag's global MNCS and PP (top 10 %) values are the largest of all six institutions. The time evolution of the field-normalised citation scores (Figure 38) shows that Eawag's impact has remained high and stable over time. Specifically, the MNCS values range from 1.65 to 1.72. Furthermore, the proportion of Eawag's publications in the top 10 % is stable and very high, with about 20 % of its publications having an impact greater than expected based on the 10 % threshold worldwide in their field. The fact that the MNCS and PP (top 10 %) indicators are consistently high and stable over time confirms that Eawag produces high-quality research.
- Eawag has published approximately 91 % of its output with some degree of collaboration and about 67 % of publications have involved at least one international partner (Figure 39). As compared to other forms of collaboration, international collaboration has led to publications with a very high impact, with an average MNCS value of 1.95 and a PP (top 10 %) of 22 %. Non-collaborative publications exhibited a high impact, with an MNCS value of 1.66, and about 22 % are among the top 10 %. Finally, publications produced in national collaboration also showed a high average impact, with an MNCS value of 1.60 and a PP (top 10 %) of 19 %.

Figure 37: Eawag's research profile. The top 19 fields of activity are shown. Together, these fields account for approximately 80 % of Eawag's output. The field-based MNCS values are computed using full counting.

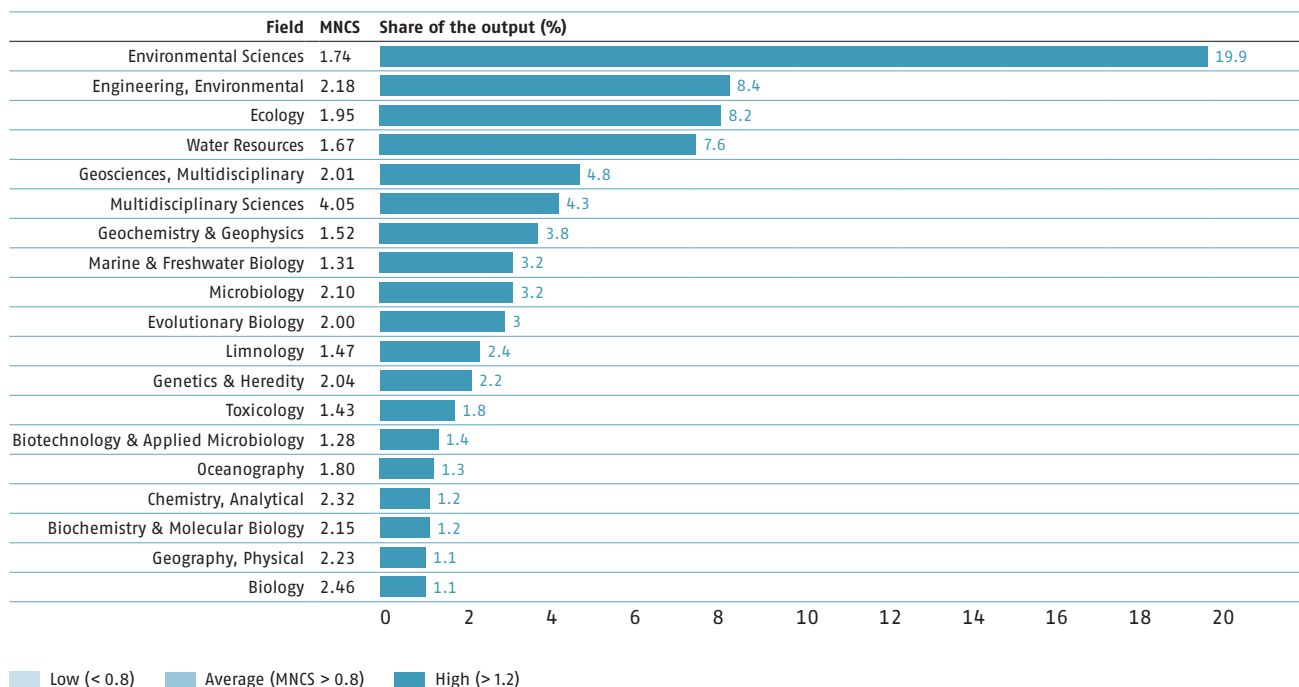


Figure 38: Time evolution of the global MNCS and PP (top 10 %) indicators (using fractional counting) for Eawag.

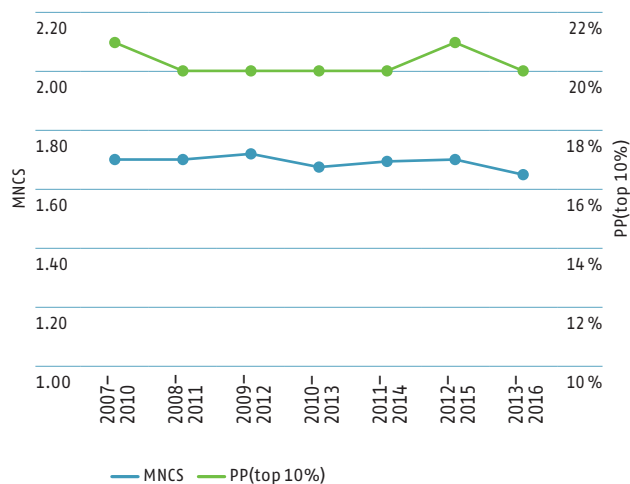
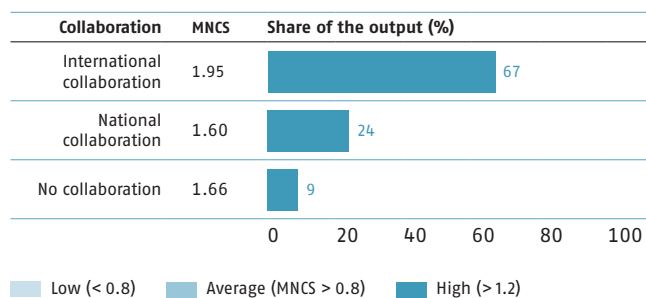


Figure 39: Collaboration Analysis for Eawag. The MNCS values are computed using full counting.



D.3 Conclusions

CWTS's bibliometric analysis confirms the excellent performance of the ETH Domain institutions in terms of publication activities. This is illustrated, among other things, by the following facts:

- There is a constant increase in the output and most importantly in the impact of the institutions' publications. It is worth noting that this was achieved despite the already very high performance shown by the previous bibliometric analyses.
- In the vast majority of the institutions' most active research fields, the impact of the publications is high. In fact there is not a single research field with low impact among all those shown in the research profiles presented in the previous pages.
- The global mean normalised citation score (MNCS) and the proportion of top 10 % publications (PP (top 10 %)) are always larger – and sometimes significantly larger – than the world average. This holds true for all institutions.

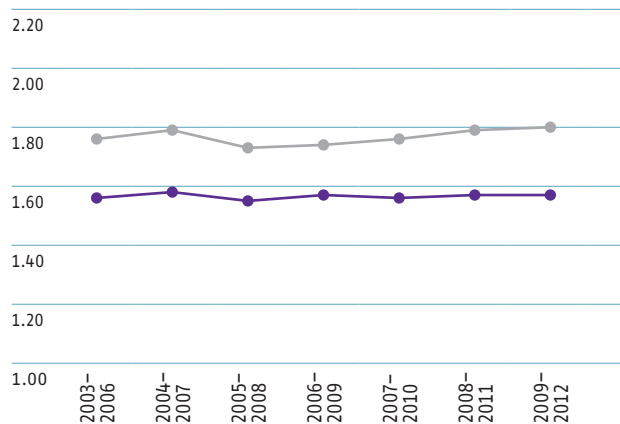
CWTS's analysis of collaboration patterns shows the importance of international collaborations and the very clear link between this type of collaborations and high-impact research. Indeed, international collaborations represent the largest share of the institutions' output. Furthermore, these publications always have the largest impact compared to national collaborations and publications published by the institutions alone.

Because of the importance of collaborative publications in an institution's output, it does not come as a surprise that the methodological change in the counting method introduced in the present study (fractional counting as opposed to the full counting method used in the previous analyses) generates significant changes in the institutions' global impact indicators. Figure 40 illustrates this by presenting the evolution of the global MNCS indicator over the period 2003–2012, which was covered by the previous bibliometric study, for all institutions. The grey lines show the results computed with the previous methodology (full counting) and the violet lines those obtained with the new methodology (fractional counting). For most institutions, the change in the methodology only results in a vertical shift, the new MNCS values being slightly smaller than the previous ones, without modification in the overall trend of the MNCS indicator. For PSI and WSL however, fractional counting results in a significant change in the time evolution of this indicator. As stated above, this may be linked to the fraction of their publications that are highly collaborative: 33 % of PSI's publications and 29 % of WSL's publications between 2007 and 2016 were co-authored by more than five different institutions, the two largest shares among all six institutions.

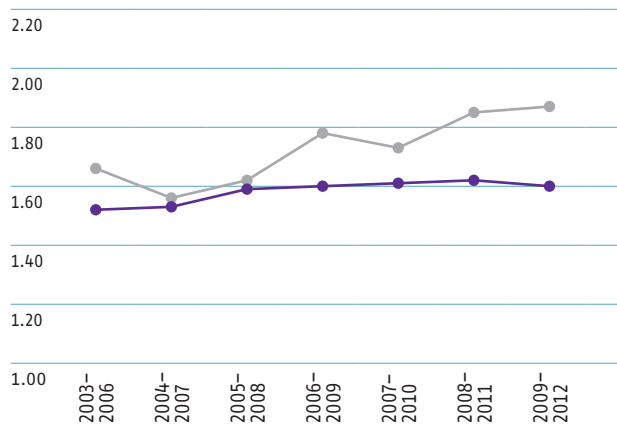
Finally, we would like to stress that, while the institutions of the ETH Domain perform very well according to the different indicators considered in this study, the image delivered by these indicators cannot claim to be complete and accurate. Moreover, it is also critical to understand that impact and scientific quality are not necessarily identical concepts. The use of bibliometric indicators for the assessment of research performance has to be complemented by background knowledge about the institutions being evaluated and about the content and nature of their research.

Figure 40: Time evolution of the MNCS indicator for the period 2003–2012, computed with the new (violet lines) and previous (gray lines) methodologies.

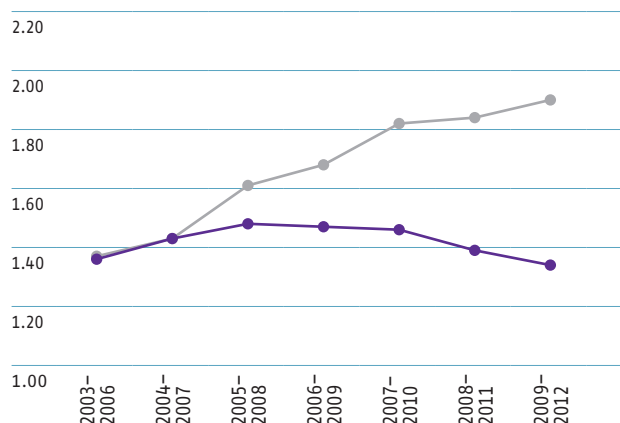
ETH-Zurich – MNCS



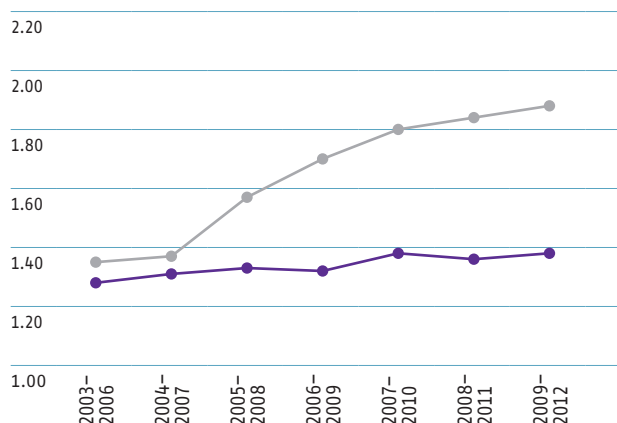
EPFL – MNCS



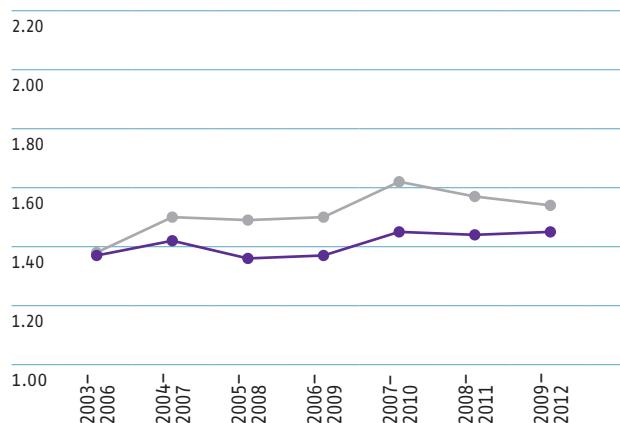
PSI – MNCS



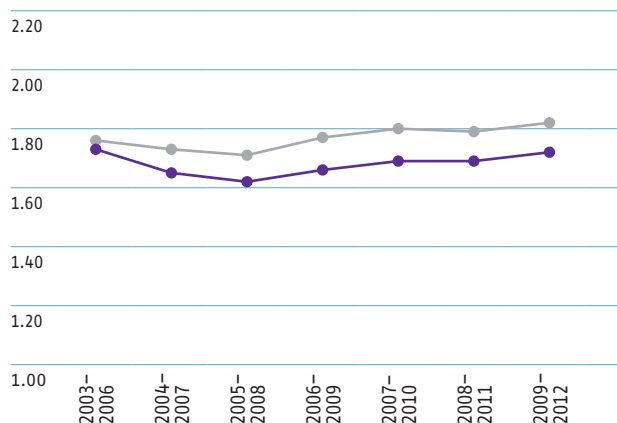
WSL – MNCS



Empa – MNCS



Eawag – MNCS



— New methodology — Previous methodology

E

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E

Analyses of the ETH Domain's Economic Contribution and Patent Portfolio

E.1 The Economic Contribution of the ETH Domain

Each franc invested in the ETH Domain generates more than five times its value in Switzerland, and each job supports almost five jobs. This demonstrates that the ETH Domain is an important actor in the Swiss national economy. With the education of specialists, its top-level research and close cooperation with business and the authorities, it makes a vital contribution towards Switzerland's competitiveness and the quality of life in this country.

In spring 2017, BiGGAR Economics, an economic consultancy firm based in Edinburgh, Scotland, was commissioned by the ETH Board to assess the impact of the institutions of the ETH Domain on Switzerland's economy and beyond, applying a broadly based and internationally well-established methodology. The study had four objectives:

- estimate the extent of the economic contribution of the institutions of the ETH Domain;
- identify the range of impacts;
- demonstrate the return on private and public investment;
- show government and authorities the benefits and positive impacts that the institutions of the ETH Domain provide.

The institutions of the ETH Domain make a decisive contribution to the economy's competitiveness and value-added and to the quality of life in Switzerland. In education, research and innovation, they play an absolutely central role with CHF 3.5bn (2016) from all their funding sources, a workforce of 21,054 employees (18,256 full time equivalents, incl. employment of doctoral students), and 30,351 students and doctoral students. Through their teaching activities, 829 professors at the institutions of the ETH Domain make a significant contribution to supplying the labour market with highly qualified personnel and management staff. In certain disciplines (e.g. mechanical and electrical engineering) ETH Zurich and EPFL are the only education providers at university level in Switzerland. With research and development, they repeatedly develop new scientific insights and achieve technological breakthroughs that lead to completely new and often disruptive technologies, displacing existing technologies, products or services. The ETH Domain is one of Switzerland's 20 most important patent applicants. It also licenses numerous inventions. The ETH Domain creates around 50 spin-off companies a year, which acquire a significant share of the venture capital in Switzerland.

The strong partnership of the ETH Domain with industry and the public sector (Confederation, cantons and municipalities) is reflected, for example, in around 500 new cooperation agreements a year with the private sector and almost 300 with the public sector⁷². This cooperation is even more intense as the ETH Domain provides small and medium-sized enterprises (SMEs) and industrial laboratories with large, expensive and resource-intensive research facilities and equipment, and runs pilot and demonstration facilities with them. Institutions of the ETH Domain are involved in various science, technology and innovation parks, offering premises and support for spin-off companies and attracting existing research-intensive companies. This also generates added value and employment.

⁷² Annual Report of the ETH Board on the ETH Domain 2017

The ETH Domain provides important support for the public sector in the fulfilment of its tasks with advice, training and joint projects. In doing so, it generates a variety of non-quantifiable, long-term benefits that are of great value to individuals, society, and science as a whole, e.g. prevention of damage caused by natural disasters through observation and modelling. Due to their uniqueness in Switzerland, the services of the ETH Domain institutions are indispensable, especially for sensitive issues such as disposal (or storage) of radioactive waste, protection against natural hazards or IT security.

E.1.1 Quantifiable Economic Contribution

Overview

The report shows that in 2016 the institutions of the ETH Domain generated an estimated CHF 13.3bn of gross value added (GVA) and employment equivalent to 98,700 jobs ("headcount") in Switzerland alone. On a global scale, and thus in total, their contributions amounted to CHF 16.5bn in GVA and about 123,800 jobs. This implies the following:

- In 2016, the institutions of the ETH Domain received around CHF 2.5bn from the Federal Government within the ETH Domain's payment framework. Thus, every franc used for direct business activities of the ETH Domain generated around CHF 5.4 in GVA in Switzerland and a total of around CHF 6.6 on a global scale.
- In 2016, the ETH Domain had 21,054 employees ("headcount"). Each job in the ETH Domain supports a total of almost five jobs in Switzerland and almost six on a global scale.

Types of economic contribution

The economic and quantifiable contributions of the ETH Domain institutions fall into two main groups: 1) direct demand and 2) indirect increase in benefits and competitiveness.

Direct demand of the ETH Domain institutions

The direct demand from all institutions of the ETH Domain and thus their GVA results from the following components:

- Core contribution: Via the core contribution of the federal government to the ETH Domain institutions (consisting of the financial contribution and the investments for buildings) a GVA of CHF 2.6bn was generated, via personnel CHF 2.0bn, suppliers CHF 0.9bn, and construction of real estate and research infrastructure CHF 0.24bn; i.e. an estimated GVA total-ling CHF 5.7bn and 40,500 jobs in Switzerland were generated.
- Student contribution: In 2016, 23,389 Bachelor's and Master's students studied at the two Federal Institutes of Technology. Student loans, student employment (outside the ETH Zurich and EPFL) and student volunteer work generated an additional CHF 0.76bn in GVA and 7,400 jobs in Switzerland through consumer demand and part-time work.
- Tourism: Students, friends and family visitors as well as participants in conferences and events of the institutions of the ETH Domain generated an estimated CHF 66m in GVA and supported almost 700 jobs in Switzerland.

This corresponds to a total of CHF 6.5bn in GVA or 49 % of the ETH Domain's total contribution to GVA generated in Switzerland in 2016.

Indirect increase in performance and competitiveness

The second group of quantifiable economic contributions includes GVA and jobs resulting from services provided by the ETH Domain, which specifically promote innovation and productivity growth in the economy and the public sector. They represent around CHF 6.74bn or 51 % of the total contribution to the GVA generated in Switzerland.

- Graduate Premium: The contribution of the ETH Domain's training activities differs fundamentally from the other contributions covered in this report, as it is spread over a much longer period. The benefits of education for individuals and society have various aspects, some of which can be quantified but many others not – as studies on health and well-being, social cohesion and spill-over benefits in the workplace have shown. For individual graduates, aspects such as social skills, self-confidence, contentment, health and well-being are relevant. Other spill-overs that are unquantifiable or at least difficult to quantify are those relating to the transfer of ETH graduates into the economy or public administration, such as diffusion of the latest knowledge, development and deployment of personal attributes such as creativity, initiative and leadership, and the associated diverse informal contacts between their employers and ETH Domain. All of this improves their employers' ability to absorb and exploit new insights and technologies. The "Graduate Premium" – i.e. the added value of an individual graduate that can be quantified in monetary terms – comprises the additional earnings that the graduate receives during his or her working life that result from their education to degree standard as opposed to a lower level of education. In the present report, the added value of an ETH graduation compared to a University of Applied Science (UAS) degree has been taken into account. This contribution is put at CHF 1.5bn for the graduates (4,600 Master's, MAS/MBA and PhDs) of the two Federal Institutes of Technology within Switzerland, and CHF 1.9bn worldwide. The Graduate Premium for ETH Zurich/EPFL graduates in comparison to the upper secondary level is significantly higher and is put at CHF 2.9bn for Switzerland and at CHF 3.8bn globally.
- Commercialisation: Institutions of the ETH Domain carry out a wide range of commercialisation activities. These include licensing inventions patented by the ETH Domain and supporting the creation of new companies. The royalties from licenses issued by the ETH Domain of around CHF 13m have been extrapolated according to values based on international experience for GVA and employment. This resulted in a GVA of CHF 0.16bn in Switzerland and CHF 0.13bn abroad, i.e. a total of CHF 0.30bn, and in employment totalling 2,400 jobs. The GVA estimate for ETH Domain spin-off companies includes all those previously created and still active in 2016, i.e. a total of 659 spin-offs. In 2016 their activities together generated an estimated CHF 2.2bn in GVA in Switzerland and 22,900 jobs.
- Knowledge transfer: The institutions of the ETH Domain support the transfer of knowledge to private and public-sector organisations: this includes services such as consulting, contract research and further education. As part of their studies, 3,000 to 4,000 students complete internships in companies averaging 12 weeks per year. In doing so, both sides benefit from new skills, new knowledge and experience. The ETH Domain provides companies with access to large world-class research facilities, e.g. for measuring times at the Swiss Light Source (SLS). As suppliers, companies benefit from their involvement in the development, construction and maintenance of these research facilities. PSI's Center for Proton Therapy, which deals with the treatment of deep-seated tumours, extends life and enhances the quality of life for its patients. Various science, technology and innovation parks in and around the ETH Domain institutions attract research-intensive companies, stimulate research collaboration and provide space and contact opportunities for ETH Domain spin-off companies as well as for external start-ups. For example, around 150 companies are active on the grounds of the

EPFL Innovation Park. All these activities help to intensify cooperation between business and academia and to promote and disseminate the application of new technologies. Knowledge transfer by the ETH Domain generates an estimated CHF 3.0bn in GVA and 27,200 jobs in Switzerland.

- Close cooperation between the institutions of the ETH Domain and other academic institutions both within Switzerland and abroad, their active exchange with the public administration and their diverse and intensive cooperation with industry mean that the full value of the knowledge-exchange activities exceeds the total of each relationship: There is a network effect. Thus, the actual GVA should exceed the figure stated above.

E.1.2 Wider, Non-quantifiable Benefits

The institutions of the ETH Domain generate non-quantifiable added value for individuals, the economy, science and society as a whole, nationally and internationally. It is essential that these services are also taken into account when assessing the ETH Domain's overall contribution.

The institutions of the ETH Domain make a significant contribution to Switzerland's attractiveness and international reputation in the fields of education, research and innovation. Investors in research and development from all over the world appreciate the proximity to highly qualified specialists and skills and high-performance research and development: it is due not least to the ETH Domain that they have chosen a Swiss location. Prominent examples from the recent past include Google, Disney Research (both in Zurich) and the Nestlé Institute of Health Sciences (in Lausanne), which operate research centres in Switzerland close to or in partnership with institutions of the ETH Domain. Traditionally very close links to the ETH Domain have been maintained by the research laboratories of IBM, ABB, Novartis and Roche. These include the partnership between ETH Zurich and IBM in the joint laboratory for nanotechnology in Rüschlikon (Canton Zurich) and the presence of leading foreign companies (e.g. IT firms such as Intel, Texas Instruments and Cisco) at EPFL's Innovation Square.

In addition, the institutions of the ETH Domain have a strong and long-standing network of cooperation ventures – both within the ETH Domain and with other universities – with private and public-sector organisations. This applies not only nationally but also worldwide. Examples include the Singapore-ETH Centre (SEC) of ETH Zurich, which launched the Swiss Technology Impact Platform (STIP) to promote business contacts in the Asian region; or the MOOCs Africa program, with which the EPFL specifically supports education and training in African partner countries. This gives rise to an intensive and rapid exchange of experiences and new insights through both formal and, in particular, informal channels – an important factor for Switzerland's highly successful education and innovation system. The highly international make-up of the institutions' students, staff and professors and their diverse networking with foreign countries results not only in good academic contacts but also in potential business ties, a supply of highly qualified people for the Swiss economy, a lively cultural exchange and greater mutual understanding.

Institutions of the ETH Domain make an important contribution to the provision of public goods. Examples include contributions to improving the ecological situation: technologies, methods and knowledge for reducing air pollution, improving the quality of water or preventing damage to landscapes and nature, and more generally for sustainable development. Scientific work deals with the quality and safety of the natural environment and its enhancement, monitoring of natural hazards (such as avalanches) and the prevention of natural disasters. In economic terms this can be expressed in the avoidance of the associated potential costs. In performing these services, institutions of the ETH Domain support and advise public administration and assist them with their decisions. All these examples have an important indirect impact, supporting the health and safety of the Swiss population and the economy more widely. Due to the ETH Domain's international networking, other countries also benefit from these services.

The institutions of the ETH Domain enjoy a strong presence in the public and in the media and make a decisive contribution to the positive image of Switzerland as a location for science. They form a strong brand with a positive aura. They evoke associations of high scientific quality, competence, mastery of new technologies, innovations and inventions. They also help substantially to stimulate interest in and acceptance of new knowledge and ground-breaking technologies in business and society – an effect that particularly supports young people in their career choice.

E.1.3 Comparisons

The extent of the ETH Domain's contribution to the economy can be put into context with results from similar studies by BiGGAR Economics on the economic contribution of higher education institutions. The leverage effect of employment with a ratio of one ETH Domain job to five in total is comparable to the ratio for Finnish universities and slightly lower than that for the LERU (League of European Research Universities) with an average of 1:6. The leverage effect of the ETH Domain on GVA of 1 CHF: 5 CHF is slightly lower than that for the Finnish universities (1:8) and LERU (1:7).

However, various factors limit the validity of direct comparisons and may in general make the performance of the ETH Domain appear smaller: 1) the lower number of ETH Zurich and EPFL graduates compared to those of foreign public universities, 2) the calculation of the Graduate Premium, which is compared to a degree from a UAS rather than a secondary level II school-leaving certificate (gymnasiale Maturität, Fach-, Berufsmaturität/maturité gymnasiale, spécialisée, professionnelle); 3) teaching and research at many universities include medicine, with its diverse links to hospitals; 4) the unique features of the ETH Domain, such as large research facilities with costly infrastructure, areas of expertise and their special ties with the economy; and 5) differences in the definition and collection of data at the individual institutions.

E.1.4 Conclusions

Switzerland has a highly effective and internationally successful innovation system, as confirmed by the Global Innovation Index⁷³. In developing and promoting this system, the institutions of the ETH Domain play a central role through their teaching and research, their highly qualified graduates, their diverse cooperation network and the quality and extent of their knowledge transfer activities. They have an influence beyond teaching and research; they influence economic and ecological quality in Switzerland as well as scientific progress and the health and social cohesion of the Swiss population.

Complete study report available at https://www.ethrat.ch/sites/default/files/BiGGAR_Studie.pdf

⁷³ <https://www.globalinnovationindex.org>

E.2 Analysis of the Patent Portfolio of the ETH Domain

E.2.1 Background

The question regarding the “return on investment” of public-funded basic research regularly comes up for debate. While the ETH Domain's basic research cannot be directly associated with concrete results in terms of products and services it can, however, be assessed in terms of scientific publications (see the bibliometric analysis in Chapter D⁷⁴) and patents. Due to the structured process of patent applications and grants, and the massive amounts of data and information available in each patent application, patents are indeed considered an interesting area of analysis⁷⁵.

The ETH Board commissioned BAK Economics AG to analyse the ETH Domain's patent portfolio using a methodology they recently developed in collaboration with the Swiss Federal Institute of Intellectual Property and PatentSight. The full study, “Analysis of the patent portfolio of the ETH Domain, Final Report, September 3rd, 2018”, by BAK Economics AG is available on the website of the ETH Board⁷⁶. In this chapter we summarise the main findings of the study⁷⁷.

E.2.2 Methodology

Traditionally, patent analyses focus on the number of patents per institution or company, without assessing the relevance of each invention (i.e. each patent is counted). The BAK Economics AG study, on the other hand, takes a new, big-data approach to evaluating the strength of each individual patent worldwide. According to this methodology, patent strength depends on two components: patent activity and patent quality. Patent activity corresponds to market coverage, i.e. the statutory coverage of the patent protection, and shows how companies assess the importance of their own invention (self-assessment). Patent quality corresponds to the relevance of the technology and, based on the references and citations of the patent by third parties, illustrates the importance of an invention compared with other patents in the corresponding technology (competitor's assessment).

The study applies these new concepts and scientific approaches to answer the following questions:

- How significant is the ETH Domain in specific technologies for Switzerland's scientific and research landscape?
- How significant is the ETH Domain with regard to world-class patents in these technologies?
- How does the ETH Domain compare to the most important international research institutions in the selected technologies?

The analysis was done for 17 specifically defined technologies and compares research quality in terms of patents of the ETH Domain to other research institutions and the industry sector in Switzerland, and to a selection of ten international research institutions among the most important ones. The technologies were defined according to the following criteria:

⁷⁴ The study presented in this chapter is also seen as complementary to the analysis of the ETH Domain's economic impact (“BiGGAR study” – see chapter E.1).

⁷⁵ An example of this trend is the recent research paper “Mapping the global influence of published research on industry and innovation” (Jefferson et al., Nature Biotechnology, 2018, volume 36, issue 1, pages 31–40). The authors' approach differs from the one developed by the study presented in this chapter: by measuring citations to scholarly works in the patents literature (whereas the BAK Economics AG study considers citations of the patents themselves), they assess the influence of published research on inventions, industry and enterprise.

⁷⁶ https://www.ethrat.ch/sites/default/files/Analysis_Patent_Portfolio_ETH_Domain.pdf

⁷⁷ Sections E.2.2 and E.2.3 are based on the management summary (pages 3–8) of the study, with modifications by the staff of the ETH Board.

- A significant share of the total patent activities of the ETH Domain should be covered.
- The technology foci of each participating institution should be included.
- The Strategic Focus Areas of the ETH Domain should be covered.

The technology transfer offices of the ETH Domain institutions were involved in the definition of these technologies. Figure 41 lists the 17 defined technologies (column 2), clustered into five technology fields (column 1). Definitions of these technologies and examples of ETH Domain patents for each of them can be found in the study.

Figure 41: Technology profile of the ETH Domain

Technology Field	Technology	Total patents	World-class patents	Patenting efficiency	ETH Domain's rank in CH
Digital / Data	Security Elements	63	17	27 %	4
Digital / Data	Quantum Technologies	22	7	32 %	1
Digital / Data	Digital Image Analysis	81	19	23 %	1
Manufact./ Materials	Advanced Materials	100	57	57 %	1
Manufact./ Materials	Nanostructures	132	48	36 %	1
Manufact./ Materials	Additive Manufacturing	34	0	0 %	–
Systems	Mass Spectroscopy	59	12	20 %	2
Systems	Drones	11	8	73 %	1
Systems	Radiation Detectors	29	16	55 %	1
Life Sciences	Biosensors, Lab-on-a-Chip, Bioprinting	53	16	30 %	2
Life Sciences	Wearables Bionics	40	9	23 %	1
Life Sciences	Radiation Diagnosis and Therapy	50	22	44 %	1
Life Sciences	Protein Engineering	122	40	33 %	4
Life Sciences	Drug Discovery Systems Biology	19	1	5 %	7
Life Sciences	Classic Organic Pharmaceutically Active Substances	24	1	4 %	45
Energy	Organic Perovskite Tandem Photovoltaics	43	24	56 %	2
Energy	Waste Water, Biomass, Carbon Capture	28	14	50 %	2
Total		910	311	34 %	

The table above shows the 17 technologies defined in the study (column 2), clustered into five technology fields (column 1); the total number of patents (column 3) of the ETH Domain in each technology; the number of world-class patents (column 4), defined as the 10 % of the highest-rated patents worldwide; the patenting efficiency (column 5), defined as the world-class patents' share of total patents for each technology; and the ETH Domain's rank in Switzerland in world-class patents, for each technology. Additive Manufacturing is not ranked due to the lack of world-class patents in this technology.

E.2.3 Key findings

A third of all analysed ETH Domain patents are world-class

Figure 41 shows the total number of patents (column 3) of the ETH Domain in each of the 17 technologies, the number of world-class patents (column 4), defined as the 10 % of the highest rated patents in each technology worldwide, and the patenting efficiency (column 5), defined as world-class patents' share of total patents for each technology.

1037 patents were owned by the ETH Domain at the end of 2017. 671 of the ETH Domain patents were identified as belonging to the 17 defined technologies as active patents in 2017. The 17 defined technologies therefore cover two thirds of all the ETH Domain's patents. The remaining 366 patents cover an extremely wide range of research areas, making it impossible to group them into technologies that can be compared on a national and international level. Some patents are attributed to more than one technology and are therefore counted more than once. This intended overlap between technologies leads to a total of 910 patent counts in the aggregation of the 17 technologies, as shown on the last line of Figure 41. The same line, column 5, shows that one third of all analysed patents can be considered world-class patents.

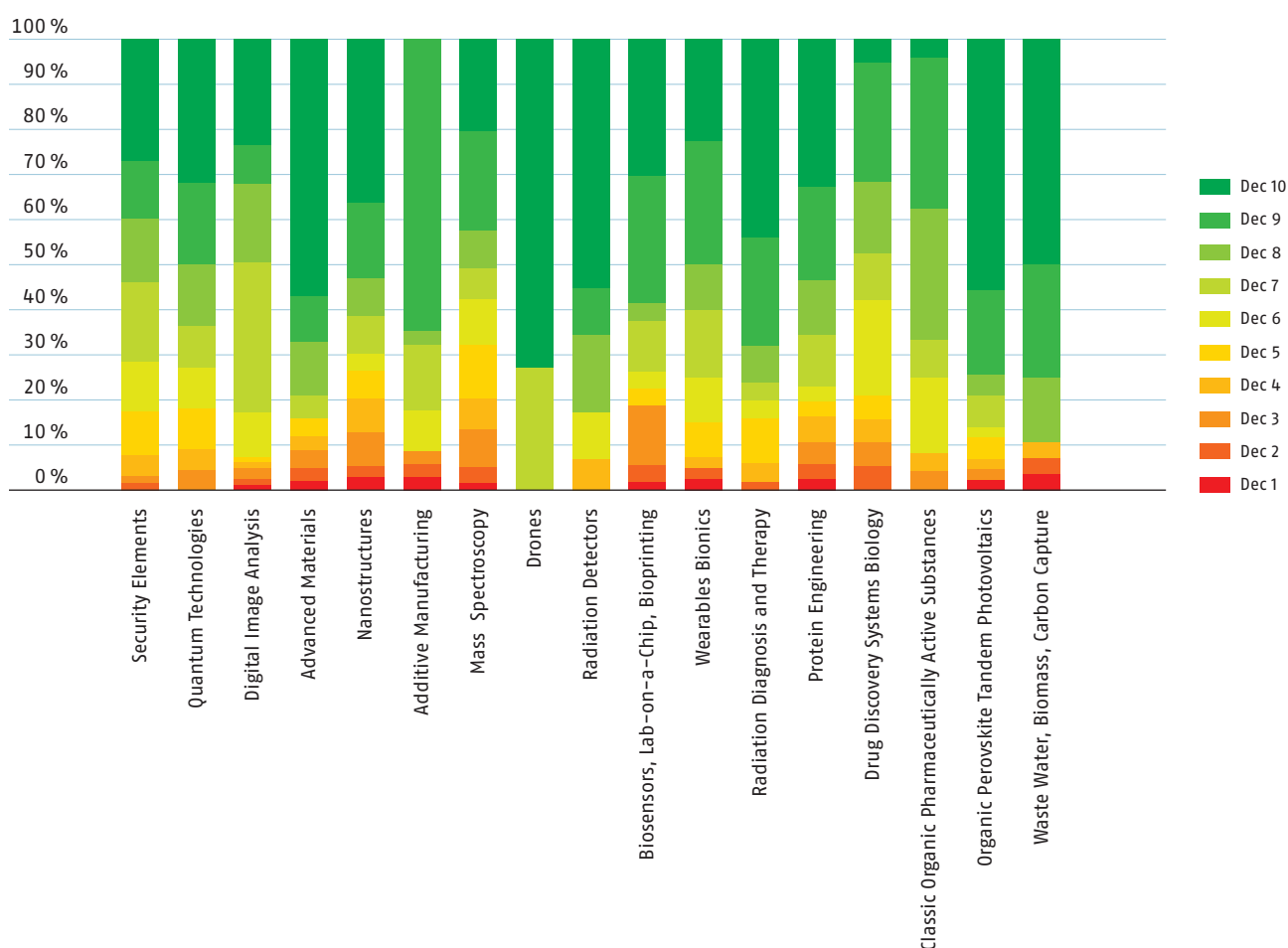
National comparison: ETH Domain in first place in 8 out of 17 technologies compared to Swiss companies and other research institutions

The national comparison of the ETH Domain with Swiss companies in world-class patents shows that the ETH Domain ranks first in 8 out of 17 technologies and in the top five in six additional technologies (last column of Figure 41). Compared to companies and other research institutions in Switzerland, the ETH Domain owns the most world-class patents in a wide range of technologies such as quantum technology, image analysis, and radiation diagnosis and therapy.

Structure of the ETH Domain's patent portfolio is of very high quality

By structuring the patent portfolio into deciles, from the top 10 % to the bottom 10 %, it can be shown (Figure 42) that the patent structure of the ETH Domain in each technology is of above-average quality. In 12 technologies, at least 50 % of the patents are of very high quality, and in the case of the energy technologies, drones and radiation detectors the top 2 deciles account for more than 70 % of the patents. Furthermore, only very few patents can be found in the low-quality deciles. This clearly demonstrates the above-average quality of the ETH Domain's patent portfolio.

Figure 42: Patent structure of the ETH Domain by technology and quality, 2017



For each technology, the patents worldwide are structured into deciles, from the top 10 % to the bottom 10 %. The figure shows the fraction of patents of the ETH Domain belonging to each decile. The colour code goes from green (decile 10, top 10 %) to red (decile 1, bottom 10 %).

International comparison: ETH Domain with third-highest research efficiency

Figure 43 shows the total number of patents and the number of world-class patents for a selection of ten of the most renowned universities and research institutions worldwide compared to the ETH Domain, as well as the patenting efficiency for each of them. It illustrates why patent analyses based on total patent counts generally lead to unsatisfactory results. For example, intellectual property in Japan is traditionally patented much earlier than in other countries. In China, researchers are incentivised to patent as much as possible in order to increase the relevance of China as a research location. Consequently, the importance of certain countries is exaggerated. For instance, the ten international institutions shown on Figure 43 own a total of almost 42,000 patents in the 17 technologies and the Chinese Academy of Sciences alone owns 19,000 of them.

Nevertheless, the general comparison of total patents and world-class patents provides some valuable insights. Although total patenting differs quite substantially between the institutions, they are comparatively close in terms of world-class patents. Consequently, patenting efficiency (share of world-class patents in total patents owned) varies among the institutions. The ETH Domain has the third-highest patenting efficiency behind Harvard University and MIT (column 4).

Figure 43: Patent overview for 10 international research institutions and the ETH Domain, 2017

Institution	Total patents	World-class patents	Patenting efficiency
Chinese Academy of Sciences	19,124	441	2 %
University of California System	5,164	949	18 %
Tsinghua University	4,968	531	11 %
Centre National de la Recherche Scientifique (CNRS)	2,925	319	11 %
Massachusetts Institute of Technology (MIT)	2,308	868	38 %
Fraunhofer-Gesellschaft	1,820	184	10 %
Stanford University	1,728	255	15 %
Harvard University	1,563	807	52 %
Japan Science and Technology Agency	1,158	110	9 %
ETH Domain	910	311	34 %
University of Oxford	431	142	33 %

The figure shows, for each institution, the total number of patents in the defined 17 technologies (column 2), the number of world-class patents (column 3), defined as the 10 % of the highest rated patents worldwide, and the patenting efficiency (column 4), defined as world-class patents' share of total patents for each technology.

International comparison: ETH Domain among the leaders in more than one third of all technologies analysed

The international comparison shows that the ETH Domain has clear advantages in system technologies such as mass spectroscopy, drones and radiation detectors. It is also ahead in security elements, where there are almost no viable competitors. Another strong development can be observed in organic perovskite tandem photovoltaics. Overall, the ETH Domain is among the leaders in more than one third of all technologies analysed.

ETH Domain ahead of European institutions

The international comparison shows the wide range of high-quality patents at the US institutions MIT, Harvard University, and the University of California System, while the other European institutions are significantly behind in the chosen technologies. The ETH Domain is positioned ahead of the European institutions but clearly behind those in the US. The two Chinese institutions considered are well positioned in many technologies. Furthermore, their patenting activities in most areas started less than 10 years ago. And yet today they are ahead of the European institutions.

Figure 44 provides an overview of the international results. The heat map is organised horizontally and labels the institutions with the highest number of world-class patents for a particular technology in green colour gradients and those with the lowest numbers in red colour gradients. Vertically, the number of green (red) cells indicates the number of high rankings (green) and low rankings (red) per institution. The large number of green fields shows the leading positions of the US institutions in the majority of technologies.

Figure 44: International comparison of world-class patents per technology, 2017

	ETH Domain	Centre National de la Recherche Scientifique (CNRS)	Fraunhofer-Gesellschaft	University of Oxford	Stanford University	Harvard University	Massachusetts Institute of Technology (MIT)	University of California System	Japan Science and Technology Agency	Chinese Academy of Sciences	Tsinghua University
Security Elements	17	0	58	0	0	1	0	1	0	0	0
Quantum Technologies	7	6	1	6	3	21	39	23	3	12	3
Digital Image Analysis	19	7	29	19	22	5	19	35	4	17	35
Advanced Materials	57	60	15	7	23	58	126	151	28	138	173
Nanostructures	48	76	21	22	36	147	203	260	44	95	209
Additive Manufacturing	0	3	9	0	5	70	47	13	1	8	3
Mass Spectroscopy	12	6	6	7	10	11	12	18	3	12	19
Drones	8	0	0	1	1	0	4	0	0	0	1
Radiation Detectors	16	0	2	0	0	0	4	1	1	4	12
Biosensors, Lab-on-a-Chip, Bioprinting	16	19	5	10	22	123	61	74	7	8	9
Wearables Bionics	9	0	5	1	6	11	32	24	1	3	0
Radiation Diagnosis and Therapy	22	7	2	3	15	7	16	33	0	6	25
Protein Engineering	40	86	10	47	86	288	218	232	15	25	12
Drug Discovery Systems Biology	1	1	0	0	15	42	28	23	0	0	1
Classic Organic Pharmaceutically Active Substances	1	12	0	1	0	15	4	11	0	5	0
Organic Perovskite Tandem Photovoltaics	24	10	6	16	4	6	13	17	0	11	2
Waste Water, Biomass, Carbon Capture	14	26	15	2	7	2	42	33	3	97	27
Total world-class patents	311	319	184	142	255	807	868	949	110	441	531

The figure shows (horizontally) the 17 technologies defined in the study and (vertically) the universities and research institutions to which the ETH Domain is compared. The numbers indicate, for each institution and technology, the number of world-class patents. The heat map is organised horizontally and labels the institutions with the highest number of world-class patents for a particular technology in green colour gradients and those with the lowest numbers in red colour gradients. Vertically, the number of green and red cells indicates the number of high rankings (green) and low rankings (red) per institution.

ETH Domain joint research projects, inventions and inventors in high demand

The ETH Domain is very active in joint research projects with industry or other research institutions.

376 co-owned patents stem from joint research projects. The ETH Domain participated in joint research for an additional 479 patents that are solely owned by the partnering company or institution. Furthermore, ETH inventions are highly relevant. 1,945 companies and research institutions worldwide cite ETH Domain inventions in 5,041 third-party patents. Former ETH Domain inventors remain very active after going on to do industry research in Switzerland: 3,801 company patents list at least one inventor who had worked and patented for the ETH Domain before joining the respective company.

E.2.4 Conclusion

The study clearly stresses the high quality of the ETH Domain patent portfolio by showing that one third of all its patents in the defined 17 technologies belong to the best 10 % worldwide ("world-class" patents). In 12 technologies, at least 50 % of the patents belong to the best 20 % worldwide. Only very few patents are of low quality according to the study.

While the ETH Domain occupies a very important place on the national and European levels, it also has the third-highest share of world-class patents compared to ten of the most renowned international research organisations, and is among the leaders in several technologies. Yet, the study also shows the predominance of the analysed US institutions. Together with the impressive recent rise in China's position, this shows that efforts and investments are still necessary to at least maintain the ETH Domain's position.

The study also clearly illustrates the impulses that the ETH Domain passes on to Swiss industry by pointing out, among other things, the many co-owned or company-owned patents which stem from joint research projects.

It must be kept in mind that, since the institutions of the ETH Domain are mainly active in basic research, only part of their research performance is reflected in patents. In addition, only the part of the ETH Domain's innovation performance that is marketable is covered by such a study. Other innovation-related activities at the ETH Domain, for example in public goods or teaching methodology, are not covered.

F

Retrospective

F.1 Implementation of the Experts' Recommendations of
the Intermediate Evaluation 2015

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F

Retrospective

F.1 Implementation of the Experts' Recommendations of the Intermediate Evaluation 2015

The evaluation mandate requires the ETH Board to report on "the extent to which the experts' recommendations made in the 2015 intermediate evaluation were implemented. If a recommendation was disregarded, reasons for this should be given."

Forty-four individual recommendations, which are grouped into 13 general recommendations, were identified by the ETH Board from the Expert Committee's report of 2015. The recommendations have been carefully considered by the ETH Board as well as by the ETH Domain institutions concerned, and have been thoroughly examined. Most recommendations have been implemented. In five cases, however, examination of the recommendation prompted the ETH Board to decide against further implementation (recommendations 3d, 10c, 12c, 13a, 13b).

The table below presents the recommendations in a short form (left-hand side) as well as the relevant information on the follow-up and the status of implementation for each recommendation, including explanations for the ones that have not been implemented. The numbering of the individual recommendations in this chapter corresponds to the structure of the experts' general recommendations as given in the document *Response of the ETH Board to the Report of the Expert Committee* of the 2015 Intermediate Evaluation⁷⁸.

Recommendation 1: Strengthening the Autonomy of the ETH Domain

1a) The tendency of limiting the autonomy of the ETH Domain – as observed in past years – should be reversed and the autonomy should be strengthened including for the four Research Institutions.	Recommendation implemented (implementation within the responsibility of the Federal authorities) Dual autonomy is a key success factor of the ETH Domain (see Chapter B.1). Autonomy is regulated by the governance of the ETH Domain and the Swiss Higher Education framework and to some extent by the ETH Act. Challenges linked to a decrease in the ETH Domain's autonomy are addressed in Chapter B.1). A working group composed of representatives of the ETH Domain institutions and of the ETH Board's staff was mandated by the ETH Board in March 2017 to analyse the framework conditions with regard to autonomy, stable and reliable core funding, as well as openness and international embedding. The conclusions of the working group were presented at the retreat meeting of the ETH Board in July 2018. For various reasons the ETH Board concluded that no further action should be taken at the moment. Ultimately, implementation of this recommendation lies mainly in the hands of the Federal authorities. With regard to the autonomy of the individual institutions, the ETH Board aims to maintain as much autonomy as possible vis-à-vis the federal authorities. It acknowledges that this also entails constantly reviewing the delimitation between the autonomy of the institutions and the autonomy of the ETH Domain. This presupposes a clear separation between the roles of the institutions and of the ETH Board.
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⁷⁸ The response of the ETH Board to the report of the expert committee of the 2015 Intermediate Evaluation is available at https://www.ethrat.ch/sites/default/files/Intermediate_Evaluation_Position_ETH_Board.pdf

Recommendation 1: Strengthening the Autonomy of the ETH Domain

1b) The content of accountability, which comes with autonomy, should be better defined.	Recommendation implemented 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 “dialog meetings”) 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 institutions’ risk management processes, internal control system and governance processes and report to the ETH Board’s Audit Committee. The ETH Board reports to the Confederation through the following main channels; – Annual reports of the ETH Board on the ETH Domain⁷⁹: The annual report is a critical self-assessment of the ETH Domain conducted by the ETH Board that is based on the Federal Council’s strategic objectives⁸⁰. The concept of this publication was revisited in 2018 in order to provide clearer and more transparent information regarding the fulfilment of the strategic objectives assigned to the ETH Domain by the Federal Council (see present chapter recommendation 9a). – Financial reports of the ETH Board on the ETH Domain⁸¹: The ETH Domain’s consolidated financial statements comprise the balance sheet, the income statement, the investment statement, the cash flow statement and notes. International Public Sector Accounting Standards (IPSAS) were implemented in the ETH Domain: in 2017 the annual financial statements were fully certified for the first time. – ETH Domain intermediate evaluations: An intermediate evaluation of the ETH Domain is conducted in the middle of every four-year performance period by the Federal Department of Economic Affairs, Education and Research (EAER). The EAER submits the intermediate evaluation’s documents to the Federal Parliament together with the funding request for the next four-year period.
1c) A coherent policy of risk assessment and management should be developed.	Recommendation implemented A review of governance and risk assessment procedures in the ETH Domain was initiated in July 2015. The existing instruments are continuously optimised both at the level of the institutions and that of the ETH Board. Under the leadership of its audit committee and supported by its internal audit unit, the ETH Board has developed a framework process for strategic decision-taking and continuous ex ante risk assessment. At the level of the institutions, risk management processes are implemented and are considered to represent an important element of strategic management. Since 2015, and due to the partial revision of the Ordinance on Federal real estate and logistics⁸², additional processes were put in place specifically for real estate-associated risk assessment and management⁸³. These run in parallel of the overall process for risk assessment but are independent from each other.

⁷⁹ Annual Report of the ETH Board on the ETH Domain 2017

⁸⁰ The Federal Council’s Strategic Objectives for the ETH Domain for the Period 2017–2020
<http://www.ethrat.ch/en/eth-board/governance-eth-domain/eri-message-strategic-objectives>

⁸¹ The Financial Report of the ETH Board on the ETH Domain 2017

⁸² Verordnung über das Immobilienmanagement und die Logistik des Bundes; available at <https://www.admin.ch/opc/de/classified-compilation/20082537/index.html> (German version)

⁸³ Additional information available upon request

Recommendation 2: Securing Stable Funding

2a) The budget of the ETH Domain should be secured over the coming planning periods as much as possible.	Recommendation implemented (implementation within the responsibility of the Federal authorities) Stable and reliable basic funding is a key success factor of the ETH Domain (see Chapter B.1). Challenges with regard to the stability of the ETH Domain's yearly budget are described in Chapter B.1.3 and Appendix B.1). As mentioned above (see recommendation 1a), a working group has been mandated by the ETH Board in March 2017 to analyse the framework conditions with regard to autonomy, stable and reliable core funding, as well as openness and international embedding. The conclusions of the working group were presented at the retreat meeting of the ETH Board in July 2018. For various reasons the ETH Board concluded that no further action should be taken at the moment. (see recommendation 1a, above). Ultimately, implementation of this recommendation lies mainly in the hands of the Federal authorities.
2b) The possibility of complementary funding such as endowments, increased overhead, development of fund raising, monetization of continuous education, strengthening of licensing income (equity, royalties, etc.), promotion of innovative financial instruments (PPP, etc.), and a review of tuition fees, should be assessed.	Recommendation implemented The ETH Board encourages the institutions to further exploit current income sources, identify new sources, and seek to benefit from new collaboration and financing models for research projects and teaching. The following income sources have been reviewed: – Increase in tuition fees: The ETH Board has decided to increase tuition fees for Bachelor and Master students by a modest amount, namely CHF 300 per year. The increase will be implemented step by step over two years from autumn 2019. The tuition fees at both Federal Institutes of Technology will be CHF 1,460 per year from 2020. The rise in tuition fees had led to intense public and political debate. It is less than originally planned and will ultimately generate additional income of about 7 million CHF. – Monetisation of continuing education: Most continuing education offerings are cost-covering. The topic of continuing education, its financing and possibilities for revenues is regularly discussed within the annual dialog meetings between the institutions and the ETH Board. – Overhead rates: The ETH Board has repeatedly demanded that a higher overhead rate be granted on research projects from SNSF, Innosuisse and Federal agencies which would cover a more substantial fraction of indirect costs. However, for the current funding period an overhead of up to a maximum of 15 % on SNSF and Innosuisse projects was decided in the context of ERI Message 2017–2020.
2c) A discussion should take place on the current and potential cantonal co-financing schemes to which not all cantons do participate.	Recommendation implemented In 2015, the ETH Board had taken note of the criteria the institutions would follow when engaging in national or international cooperation. (For details concerning these criteria, please refer to Chapter A.5.2). Academic benefits of external locations should by far exceed financial aspects. As indicated in the present chapter under recommendation 5a, the ETH Domain institutions have each investigated the benefits and costs of their external sites. Cantons (and cities/communities) often help to cover costs of these sites in terms of infrastructure, personal costs (including joint professorships) or real estate, by funding projects or by providing other favourable conditions. These financial benefits vary from site to site.

Recommendation 3: Reinforcing the Strategic Capacity of the ETH Board

- 3a) The strategic capacity of the ETH Board should be strengthened.

Recommendation implemented

With regard to strengthening its general strategic capacities, the ETH Board emphasises that this does not concern the general competency of the Board and its members but the possibility of focusing its work on the issues that are strategically relevant. For that, the ETH Board has started a process aimed at increasing the efficiency of the ETH Board meetings and thus reducing the workload.

Concrete examples include:

- ETH Board meeting's agenda is optimised to reserve considerably more time for strategic discussions than for items that do not require discussion in depth.
- At each meeting the three internal members give a short account on important strategic developments and achievements at the institutions they represent.
- Mandating of working groups, for example:
 - For reviewing the process of the yearly budget allocation to the institutions. Based upon this review the ETH Board has introduced a more strategy-oriented model for budget allocation (ETH Board meetings, December 2017 and September 2018).
 - For assessing the legal framework of the ETH Domain with the aim of sustaining the Domain's key success factors in the long term.
- The commissioning of studies from external parties.

The ETH Board is striving to allocate more time to discussing and taking decisions on strategic items (see also position on recommendation 4a of the present chapter).

- 3b) The ETH Board has to find the appropriate balance between internal competition and creating synergies in cooperation among its member institutions.

Recommendations implemented

The ETH Domain institutions are engaged in a large number of cooperation projects and initiatives. Various examples of successful collaboration and coordination in teaching as well as in research, research infrastructures and knowledge and technology transfer, both within and outside of the ETH Domain, are described in Chapter A.3. Joint professorships are also excellent vectors for collaboration (see Chapter A.4.2).

- 3c) The ETH Board must foster cooperation between the ETH Domain and the universities as well as the universities of applied sciences (UAS).

Since 2017, and under the new Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA), the ETH Domain institutions, as well as the UAS, can apply and receive federal project contributions (Projektgebundene Beiträge, Contributions liées à des projets). These contributions favour innovative cooperation projects between the different actors of the Swiss higher education sector. The institutions of the ETH Domain are participating in a number of the federal projects for the period 2017–2020, for which they collaborate with other Swiss higher education institutions⁸⁴.

Competition is more at play at the level of research and funding, as well as for the recruitment of the best talents. Given the number of good examples of cooperation projects and after assessing the current situation, the ETH Board is convinced that the balance between cooperation and competition is not currently an area of concern.

- 3d) The ETH Board should consider the merits of establishing a strategic fund.

Recommendation examined but not implemented

The ETH Board is opposed to the recommendation of establishing a strategic fund on its own behalf. It considers that it has neither the capacity nor the role of a funding agency. Most importantly, it does not have (nor should it have) the competencies to assess projects in accordance with established standards pertaining to scientific review processes. Again, bottom-up cooperation proves to be more successful than top-down strategic cooperation initiatives.

⁸⁴ Details about projects and proposals, as well as participation by the ETH Domain institutions, available at (<https://www.swissuniversities.ch/en/organisation/projects-and-programmes>)

Recommendation 3: Reinforcing the Strategic Capacity of the ETH Board

3e) Competencies of the ETH Domain institutions could be pooled and shared whenever appropriate.	Recommendations implemented The ETH Board attaches great importance to observing the institutions' autonomy in terms of organisation. They have always seized opportunities to engage in pooling competencies in their own initiatives and already shared and pooled a certain number of competencies. Examples of pooled competencies include: – Libraries: The four research institutions run a common library (Lib4RI; see Chapter A.4.2). ETH Zurich library, EPFL library and Lib4RI are all part of NEBIS (network of Swiss libraries). ETH Zurich, EPFL and PSI participate in different parts of the Federal cooperation projects P2 (2012–2016) and P5 (2017–2020) "Scientific information: Access, processing and safeguarding". – Joint procurement: KoBe ETH+, which is a joint initiative of all the ETH Domain institutions to provide coordinated procurement within the ETH Domain. – IPSAS and reporting: The ETH Domain has created a "Competence Center IPSAS ETH Domain" for the uniform establishment and application of IPSAS. The four research institutions have developed a common SAP-FC platform (SAP4FOUR) and work together to put in place and operate SAP-FC in accordance with IPSAS standards. – Equal opportunities: The institutions of the ETH Domain jointly run the programme <i>Fix the leaky pipeline!</i> for mentoring their female doctoral students and post-doctoral fellows. The programme is co-financed by the ETH Board and all the institutions. The ETH Domain's Equal Opportunities working group (with representatives of all the institutions) meets regularly to exchange best practices. This working group also allows an exchange of best practices and cooperation in the Domain of dual career hiring (note that this point is also covered in the Gender Strategy – see present chapter, recommendation 7a).
3f) The cooperation on dual career hiring should be fostered at the level of the ETH Domain.	

Recommendation 4: Reviewing the Organisation of the ETH Board

4a) The work of the ETH Board should focus on strategic issues; operational activities should be left to member institutions to the maximum extent possible.	Recommendation implemented Whenever possible, tasks, particularly coordination between institutions and operational issues, are delegated to the Executive Committee or to the Domain meeting, as well as to working groups. The ETH Board pursues a case-by-case approach in this regard (see also recommendation 3a of the present chapter)
4b) The ETH Board should take steps to have its seat and central activity moved to Bern.	Recommendation implemented The ETH Board has principle offices in Zurich and Bern. Both locations will be maintained. At the same time, the ETH Board is expanding its activities and staff in Bern in order, among other things, to ensure that Switzerland's various regions are represented within the ETH Board's staff. – Expanding the presence in Bern has proved to be efficient for recruiting more diverse personnel in term of culture and language. Under the current presidency of the ETH Board, this cultural mix has improved steadily over the past five years. The proportion of French native speakers increased from 10 % in 2013 to 22 % in 2017, while that of Italian speakers remained at 2–4 %. – In autumn 2018, the ETH Board moved its current office in Bern to a more spacious location. The new location provides for both fixed and flexible workplaces. In addition, the provision of meeting rooms makes it possible to host meetings of the ETH Board and ETH Domain committees, as well as further ETH Domain-relevant meetings and activities. – The presence in the Federal capital of the President and the members of the ETH Board, as well as its Executive Director and the head of Communication, has been further intensified to foster networking with the Federal authorities, political parties and other interest groups (see "Communication strategy" under recommendation 9a of the present chapter).

Recommendation 4: Reviewing the Organisation of the ETH Board

4c) The working method of the ETH Board needs to be reviewed in order to ease the administrative burden.	Recommendations implemented Knowledge about internal processes is essential for providing transparent and necessary information to institution heads, to the ETH Board or to the Federal Administration. However, this task entails a certain administrative workload. The ETH Domain institutions are constantly seeking the right balance between the administrative tasks required for gathering knowledge about internal processes and the resources they invest in their main tasks (education, research and knowledge and technology transfer).
4d) The State Secretariat and the ETH Board should review the situation of increasing administrative burden and propose appropriate measures.	The institutions have had held extensively exchanges on that topic and on the aspects giving rise to an increased administrative burden in the ETH Domain ⁸⁵ .
4e) The lack of international representation in the ETH Board should be reviewed. The Swiss government should re-assess the situation.	Recommendation implemented (implementation within the responsibility of the Federal authorities) The ETH Board is open to the notion of appointing international members to the ETH Board and would welcome a renewed effort by the Federal Council to work towards this goal. Thus, while the ETH Board had agreed with this recommendation, its implementation is the responsibility of the Federal Council. Even though no international member was elected at the last renewal of the ETH Board by the Federal Council, it should be noted that the ETH Board members have considerable international experience and a strong international perspective.

Recommendation 5: Intensifying the Relations Between the ETH Domain and the Cantons

5a) A strategic monitoring of the outcomes of the different approaches within the ETH Domain regarding partnerships, territorial implantations and co-financing by the cantons should be carried out. The results of this monitoring should be made transparent.	Recommendation implemented The ETH Domain institutions carefully assessed the benefits and costs of their interactions with cantons regarding external sites and reported the outcome to the ETH Board in 2018 ⁸⁶ . Risks related to external sites are assessed in the context of the yearly Institution's Report on Risk Management (see present chapter, recommendation 1c). For further details concerning external sites and outcome of interactions with cantons, see Chapter A.5.
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⁸⁵ A review of this discussion that focuses on concrete examples is available upon request.

⁸⁶ The ETH Board took note of the individual reports on July 4/5, 2018. These reports are available upon request.

Recommendation 6: Fostering Research Infrastructures

6a) Appropriate means should be ensured for the long-term planning of technology platforms and large-scale research facilities with stable budget.	Recommendations implemented Within the framework of the Swiss Roadmap for Research Infrastructures 2015, the ETH Board approved the implementation plans of six research infrastructures of the ETH Domain for the period 2017–2020 (see Chapter A.1.3). An update of the Roadmap will be published in 2019 as part of the planning process for the ERI-period 2021–2024.
6b) The ETH Domain plays a key role in further developing the national roadmap for future large-scale infrastructures and in the participation of Switzerland in international initiatives.	Recommendations implemented Compared to the Swiss Roadmap 2015, the SERI involved the stakeholders (working group with representatives of ETH Board, swissuniversities and SNSF) early on in the development of the Roadmap 2019. The SERI leads and coordinates the overall Roadmap process; the responsibilities of the ETH Board are: – Coordinating the national research infrastructures of the institutions of the ETH Domain; – Evaluating the implementation and funding of these research infrastructures; – Deciding on the inclusion of these research infrastructures in the Roadmap 2019 (positive scientific evaluation by the SNSF required) and the strategic planning of the ETH Board for the ETH Domain. The institutions of the ETH Domain allocate considerable financial resources to ensure the state-of-the-art performance, long-term operation and further development of the large-scale research facilities for the national and international scientific community, and for users from industry. Major upgrades of these facilities are planned in due time and in a coordinated manner in order to stay internationally competitive and to maintain Switzerland's excellent global position in this competency area.

Recommendation 7: Striving for Gender Diversity

7a) A clear gender diversity and equality of opportunity policy should be formulated and implemented.	Recommendation implemented In 2017, with the objective of continuing to increase the proportion of women in the ETH Domain in the coming years, the ETH Board launched a Gender Strategy for the period 2017–2020. It is an overarching strategy to foster gender balance and equal opportunities for women and men within the ETH Domain. It provides a clear and coherent policy for the entire ETH Domain. The individual ETH Domain institutions are responsible for implementing the Gender Strategy through adequate actions that match their respective situation. The Gender Strategy can be found in the Appendix to Chapter A.2.
7b) Monitoring of the implementation of the policy should be enhanced (incl. possible benchmarking against best practices at comparable institutions worldwide).	Recommendation implemented The ETH Domain institutions regularly provide reports to the ETH Board with a description of measures implemented in the context of the Gender Strategy, and an indication of the funds invested in this area. Both Federal Institutes of Technology perform detailed gender monitoring (every year for ETH Zurich and every two years for EPFL) to assess gender balance amongst their members. These reports may include benchmarking. Proportions of women and men within all six institutions of the ETH Domain are also monitored in the context of the Annual Report of the ETH Board on the ETH Domain ⁸⁷ . The ETH Domain institutions (through the working group on Equal Opportunities) assess measures practised within the ETH Domain, in Switzerland or in other countries, particularly within universities and research institutes but also within partner companies.

⁸⁷ Annual Report of the ETH Board on the ETH Domain 2017

Recommendation 7: Striving for Gender Diversity

- 7c) The possibility of providing incentives and quantitative targets to accelerate implementation shall be examined.

Recommendation implemented

In the past the ETH Board has repeatedly discussed this idea but is reluctant to set overarching quantitative targets for diversity or to provide specific incentives to achieve them. However, the ETH Domain institutions implement quantitative targets in some of their internal processes. For example,

- At ETH Zurich, there are at least two female professors in faculty recruiting committees and at least one potentially eligible female candidate is invited for the interview.
- At EPFL, there are at least two women in search committees and the shortlist of candidates to be interviewed also contains at least two women. Additionally, the proportion of women candidates to be interviewed should be comparable to or higher than that of female PhD students in the relevant field at EPFL.
- In its Gender Action Plan 2017–2020, PSI commits to a target of at least 15 % of women in strategic or career-relevant decision-making bodies.

The ETH Board also recognises that investments are warranted to support initiatives that would implement measures with proven success in promoting diversity. Thus, the Strategic Planning of the ETH Board for the ETH Domain for the period 2017–2020 stipulates that the member institutions spend at least 0.4 % of the Confederation's annual contribution for implementing measures supporting the promotion of equal opportunities. The ETH Board verifies that adequate funds are reserved for measures implemented within the Gender Strategy (in the context of the reports regularly provided to the ETH Board – see above, recommendation 7b).

Recommendation 8: Improving Graduation Rates

- 8a) A gap is existing between the learning outcome of the Matura and the success rate of students in the first year of their bachelor studies at ETH Zurich and EPFL. Efforts for improving the quality of the Matura and to close the above-mentioned gap should be strengthened.

Implementation not within the responsibility of the ETH Board

The ETH Board is grateful for the efforts undertaken by all ETH Domain institutions to strengthen students' competencies in STEM⁸⁸ disciplines. ETH Zurich and EPFL are working closely with Swiss baccalaureate schools (Gymnasium/gymnase) to improve the transition phase between Swiss baccalaureate schools and University. Both ETH provide tools to students for assessing their level and courses to improve their competencies.

Nevertheless, the ETH Board considers that specific measures for strengthening the baccalaureate (Maturität/maturité) must primarily be defined, decided and implemented by the cantons (with the support of the Confederation), as the baccalaureate schools are in their area of responsibility. Therefore, implementation of the recommendation is not within the responsibility of the ETH Board.

- 8b) The possibility of a selective admission for students holding foreign qualifications at ETH Zurich and EPFL should be considered.

Recommendation implemented

In 2016, the Swiss parliament adopted a proposition by the ETH Board to amend an article of the ETH Act in that direction. The new Article 16a al. 1 of the ETH Act is in force and reads:

Art. 16a Limits on admission

¹ The ETH Board may, at the request of the [ETH Zurich or EPFL] Executive Board, limit admission to the Bachelor's degree cycle or to the Master's cycle for students holding foreign qualifications if there is insufficient capacity. The limits may apply to specific fields of study or to the total number of study places available at the federal institute of technology.

⁸⁸ STEM (science, technology, engineering and mathematics) incl. computer and communication sciences in analogy to the German term MINT (Mathematik, Informatik, Naturwissenschaften, Technik).

Recommendation 8: Improving Graduation Rates

- 8c) For students with a Swiss certificate, the option of a non-compulsory, informative entrance assessment, as practiced in some areas by some universities and UAS, should be taken into consideration.

Recommendation implemented

The ETH Board, together with the ETH Domain institutions, clearly maintains that the baccalaureate must remain the entry ticket to commence Bachelor studies at ETH Zurich and EPFL, even if this means that first-attempt success rates at examinations at the end of the first year may be lower than at foreign universities with selective admission policies. The existing, already very considerable efforts to help future students assess and improve their skills are strongly supported by the ETH Board. ETH Zurich and EPFL will continue their manifold efforts in this regard to further encourage and inform prospective students interested in studying at one of the two universities (see also recommendation 8a).

Recommendation 9: Improving Communication and Dialogue Capacities

- 9a) The dialogue with the population and its representatives towards a better mutual understanding should be improved and intensified.
- 9b) The ETH Board should develop a strong communication strategy to increase information of and interaction with the public in general and political representatives on one side, and to foster ways to better listen and understand societal concerns on the other side.

Recommendations implemented

The ETH Board's communications strategy was adapted in early 2017 primarily with the aim of fostering and intensifying the dialogue with public authorities, politicians and society and, more generally, to promote understanding of the functioning of science and universities in politics and society. Examples of measures and actions include:

- **Public Affairs:** Concrete measures include establishing regular meetings with diverse political parties and groups in "federal" Bern, the exchange on specific topics with umbrella organisations, and favouring targeted media relations and the publication of facts and opinions when pertinent.
- **Social media and online communication:** The ETH Board has recently increased its social media activities by creating and running a Twitter account. An Online Information Portal is under development that will facilitate the efficient use of social media and reach a larger audience.
- **Reporting:** One of the key communication tools of the ETH Board is its annual report to the Federal Government⁸⁹. The concept of this publication was revisited in 2018 in order to provide clearer and more targeted information regarding the fulfilment of the Federal Council's strategic objectives for the ETH Domain⁹⁰.
- **ETH Domain and society:** Special events are used increasingly to intensify the dialogue with politics, economy and society. ETH Domain is present, for example, at the World Economic Forum and the Swiss Economic Forum, and open days are held at the ETH Domain institutions.

The outcome of these measures will be regularly monitored.

- 9c) Communication on how science is able to contribute to political decision-making should be enhanced.

Recommendation implemented

The institutions of the ETH Domain advise authorities on the development or updating of regulations in a number of areas. Some examples are cited in Chapter A.1.4. The ETH Board's communications team ensures that successful examples of evidence-based policy-making are duly communicated whenever possible⁹¹.

⁸⁹ Annual Report of the ETH Board on the ETH Domain 2017

⁹⁰ The Federal Council's Strategic Objectives for the ETH Domain for the Period 2017–2020

⁹¹ A list of examples was compiled by the institutions and presented as written information to the ETH Board in July 2018. This document is available upon request.

Recommendation 10: Enhancing the Collaboration with the Universities of Applied Sciences

- 10a) The passerelles between curricula (of universities of applied sciences –UAS – and ETH) should be strengthened.

Recommendation implemented

Possibilities for transition between the different types of universities in Switzerland are important, both at the individual level but also for the higher education system as a whole. Regulations already exist governing such transitions from Bachelor to Master level. Additional qualifications are required for these transitions. Thus students who have missed out on theoretical basics must acquire this knowledge before transferring from a university of applied sciences (UAS) to a Federal Institute of Technology; and conversely, students who have not yet acquired practical or professional experience must acquire this before transferring from a Federal Institute of Technology to a UAS. ETH Zurich and EPFL both apply well-established procedures that govern the “passerelles” between Bachelor and Master studies (from a UAS to a Federal Institute of Technology). The conditions are described in the respective ordinances and regulations, and are published on ETH Zurich’s and EPFL’s websites.

In addition to the “passerelles”, it is important to note that cooperation between the ETH Domain and the UAS has been consolidated through collaborative projects and joint professorships (see recommendation 3b above).

- 10b) Transfer from fundamental research created within the ETH Domain to market through better utilization of applied research and development created within UAS must be supported.

Recommendation implemented

The ETH Domain has proposed that the BRIDGE programme be extended as a funding instrument at the intersection of basic research and science-based innovation. This programme is a first step towards responding to the urgent need for instruments for collaborative research and other common activities between ETH Domain institutions and UAS. BRIDGE is run jointly by the SNSF and Innosuisse – the Swiss Innovation Agency.

BRIDGE consists of two funding opportunities:

- **Proof of Concept** is aimed at young researchers who wish to develop an application or service based on their research results. These projects may target innovations of all kinds from any area of research.
- **Discovery** is aimed at experienced researchers who aim to explore and implement the innovation potential of research results. Only technological innovations that have a societal and economic impact will be funded.

These two funding schemes have separate and independent evaluation procedures and committees. There have already been three calls for the Proof of Concept scheme. A total of 150 applications were submitted and 20 funding requests were approved. The scheme Discovery has made its first call for projects in 2018 and has attracted 200 applications. The large number of project submissions is a clear indication of the high demand and interest in the programme and more generally in pre-competitive research.

- 10c) Financial incentives targeted towards collaboration between ETH Domain institutions and universities on one side, and universities of applied sciences on the other side, should be proposed together with interested partners.

Recommendation examined but not implemented

Collaboration will be further strengthened but must continue to be driven by mutual interest and complementarity of competencies. This is best guaranteed in environments that allow and foster bottom-up initiatives in research and teaching. Financial incentives are considered neither necessary nor suitable as a means of intensifying collaboration.

Therefore, the ETH Board is opposed to introducing such incentives. Financial support for collaborations cannot come from the ETH Board, nor should it be limited to certain models of partnerships or innovation models or KTT. However, new competitive funding instruments such as the BRIDGE programme (see above under recommendation 10b) will facilitate collaboration between the ETH Domain and the UAS.

Since 2017, and under the new Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA), the ETH Domain institutions, as well as the UAS, can apply for and receive Federal project contributions (Projektgebundene Beiträge, Contributions liées à des projets). These competitive contributions favour innovative cooperation projects between the different actors in the Swiss higher education sector. A certain number of these projects are collaborations between ETH Domain institutions and UAS.

Recommendation 11: Defining a Strategy Relative to the Medical and Health Field

11a) The evolution of medical curricula towards greater Bologna compatibility should be supported. 11b) A strategy on how the institutions of the ETH Domain can contribute in increasing productivity in the health care sector, in order to compensate for the shortage of health care professionals should be defined.	Recommendations implemented The Bachelor study programme in Human Medicine was successfully launched at ETH Zurich in autumn 2017, and EPFL offers a “passerelle”, a highly selective one-year programme for its students who wish to study medicine at the University of Lausanne or the University of Geneva after they have completed their Bachelor's degree in life sciences engineering (see Chapter A.1.1).
11c) The vision and the role of the institutions of the ETH Domain regarding precision medicine and translational medical research should be sharpened. 11d) A strategy with the main actors regarding public health, including the potential contribution of the institutions of the ETH Domain in prevention and health promotion, should be defined. 11e) It should be defined where the institutions of the ETH Domain could and should take leadership.	Recommendations implemented Personalized Health and Related Technologies (PHRT) is one of the Strategic Focus Areas of the ETH Domain for the period 2017–2020. For details concerning PHRT, see Chapter C.1.1. In addition to the PHRT initiative and singled-out research projects, examples of the institutions' contributions in the area of health include: – ETH Zurich, the University of Zurich and the Zurich University Hospital established the Center for Precision Medicine Research in 2018. – Patients with certain types of cancer can benefit from proton therapy offered at the PSI Center for Proton Therapy. In addition, the PSI Education Center offers training and continuing education in the area of ionising radiation for medical purposes. – The institutions of the ETH Domain also advise authorities on drawing up their policies (see present chapter, recommendation 9c). Some of these policies may benefit public health via prevention or health promotion schemes. See Chapter A.5.4, for a description of cooperation between ETH Zurich and other Swiss universities and university hospitals in the field of medicine.

Recommendation 12: Developing Better Entrepreneurship and Innovation Capacity

12a)	The commitment to innovation and entrepreneurship should be reinforced.	Recommendation implemented The ETH Domain institutions are already providing an impressive amount of work and develop numerous instruments in this area. The Domain's commitment to innovation and entrepreneurship is thus an ongoing process. This topic is covered in Chapter A.1.4 and A.2.
12b)	A stronger culture of entrepreneurship among the student body, faculty and research staff should be developed. Whenever applicable, resources and incentives could be applied to these efforts.	Recommendation implemented In order to stimulate the creation of spin-offs and to support their entrepreneurs from the very beginning, the ETH Domain institutions offer a comprehensive set of instruments to identify, foster, promote and develop the entrepreneurial aptitudes of their students and collaborators. This topic is covered in Chapter A.2.
12c)	The creation of formal (possibly externally funded) seed or venture funds should be considered.	Recommendation examined but not implemented ETH Board strongly feels that it is not its role to establish or control a venture fund itself, as this is not – nor should it be – part of its mission as a strategic authority. ETH Board acknowledges the positive role such instruments play in encouraging entrepreneurship. It considers that it can play a role in raising awareness about the importance of these instruments, which may help in encouraging private investors to create this type of fund. The ETH Board, together with the institutions of the ETH Domain, can share experiences and contribute to setting up fruitful framework conditions, allowing start-ups and spin-offs to make effective use of such funding instruments. To that end, a common website (https://spied.ch/) depicting all spin-offs of the ETH Domain has been created on which interested spin-offs publish their investment opportunities. Potential investors can directly access information about these spin-offs and establish contact with them.
12d)	Practices and expertise should be shared among the institutions, especially between the universities and research institutes.	Recommendations implemented The ETH Domain patent portfolio analysis performed by BAK Economics AG provides good pointers to the importance and impact of the ETH Domain in selected technologies in comparison with other Swiss institutions, but also internationally (see Chapter E.2 for a summary of the study).
12e)	Measures of success and appropriate benchmarking criteria should be selected.	In 2016, the ETH Board set up a working group to identify suitable additional indicators for monitoring KTT within the ETH Domain. The selected additional indicators have been implemented since 2017 and are now an integral part of the monitoring performed in the context of the Annual Report of the ETH Board on the ETH Domain ⁹² . The KTT indicators for the ETH Domain are presented in Chapter A.1.4.

⁹² Annual Report of the ETH Board on the ETH Domain 2017

Recommendation 13: Defining the Role of the ETH Domain Components Regarding the Innovation Park

13a) The ETH Board needs to take a more proactive role in view of the national importance of the innovation issue in connection with the Swiss Innovation Park (SIP).	Recommendation examined but not implemented The initiative and responsibility for the ETH Domain's participation in the two hubs and the network locations of Switzerland Innovation (formerly Swiss Innovation Park SIP) lie with the institutions. Planning and commitments by the institutions must be financed with the resources available to their own ordinary budgets, possibly topped up with third-party funding. Thus, the Zurich and Lausanne hubs are a matter for ETH Zurich/Empa and EPFL respectively, though the project lead is with the cantons. The ETH Board, however, is pleased to note that the institutions have acted in a proactive and constructive manner. The ETH Board has remained in the background and does not consider it necessary or suitable to assume a more active role. The institutions have undertaken various actions in regard to innovation parks; these are summarised in the Chapter A.2.2.
13b) The ETH Board should analyse the many already existing success and failure stories of innovation parks abroad and draw the appropriate conclusions.	Recommendation examined but not implemented Existing studies on the strengths and weaknesses of innovation parks abroad include those on Berlin-Adlershof, Cambridge Science Park and High Tech Campus Eindhoven. Relevant aspects include, for example, the immediate vicinity of highly competent university labs and renowned companies, a competent location management, acquisition efforts by companies worldwide and the support of the relevant political institutions. For the time being, the ETH Board does not see the need to go into further details.

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