



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

Cover photo

The Strategic Focus Area Data Science (cf. p. 25) is aiming to accelerate the adoption of data science and machine learning techniques within the academic disciplines of the ETH Domain and throughout the scientific community and the industrial sector. (Image: Swiss Data Science Center)

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Foreword by the President of the ETH Board



Dear readers,

The ETH Domain faces unprecedented calls to provide both a sound scientific basis and sustainable solutions to increasingly complex environmental and technological challenges – which themselves reflect pressing societal needs. Public and political stakeholders' expectations of rapid and straightforward 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.

With its Strategic Planning for 2021–2024, the ETH Board together with the six institutions sets out the strategic initiatives and measures through which it intends to master these challenges. The ETH Board is convinced that the core contribution of the ETH Domain institutions to innovation lies in their excellent performance in terms of research and teaching. Therefore, innovative, research-based training with the highest possible standard of supervision is an absolute priority. The growing number of students, doctoral students and professors, coupled with the diversification of curricula and learning environments have created a need for more investment in teaching, training and learning infrastructure at the six institutions. To enable Switzerland to acquire the necessary know-how in pioneering fields of research (e.g. artificial intelligence) that are increasingly relevant to society, the economy and the environment, the six institutions need to increase the number of professors and research groups. This will ensure strong links between training and state-of-the-art research, create new opportunities in research and teaching, strengthen established areas of research and enable us to advance into new ones. In addition, this capacity-building and expansion of existing competencies will enhance the ETH Domains' capacity to anticipate and respond to the country's challenges – for example, to put forward adaptation and mitigation options for tackling climate change. It will also provide the necessary scientific and technical basis support for initiatives of its authorities, e.g. in energy research or digitalisation-related activities.

To continuously fulfil the ETH Domain's mandate in the Swiss context, favourable framework conditions must be created for the Domain's institutions and the Swiss higher education and research system. This will safeguard the three key success factors – namely i) internationality and openness, ii) the autonomy of both the ETH Domain as a whole and of the Domain's institutions, and iii) stable and reliable funding by the Confederation. With respect to the 2021–2024 period, the ETH Board feels it is vital that scientists working in Swiss research institutions should have access to international networks and international competitive research funding, notably the 9th European Framework Programme for Research and Innovation 2021–2027 ("Horizon Europe") and the Euratom research and training programme.

In order to implement its strategy with the related measures, the ETH Board is asking the Federal Council and Parliament to approve a budget appropriation of CHF 11,053 million for the ETH Domain for the period 2021–2024. On the basis of the current financial planning for the year 2020, this amount would represent a mean annual growth rate of 3.1% (including compensation for an assumed annual inflation rate of 1%).

A handwritten signature in black ink, appearing to read 'F. Schiesser'.

Dr Fritz Schiesser
President of the ETH Board

Executive summary

Challenges

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.

In order to respond to an increasingly dynamic environment, all 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;
- enhance their reputation and visibility internationally in order to attract, retain, train and foster the best scientific talent as well as highly qualified administrative and technical staff, 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.

Strategic initiatives and measures

With its Strategic Planning for 2021–2024, the ETH Board together with the six institutions sets out the strategic initiatives and measures through which it intends to master these challenges:

In order to respond to an increasingly dynamic environment, the ETH Domain institutions are challenged to push their already excellent academic performance to even higher levels.

Innovative, research-based education: Innovative, research-based training with optimum supervision is an absolute priority. The growing number of students, doctoral students and professors, coupled with the diversification of curricula and learning environments, have created a need for more investment in teaching, training and learning infrastructure at the six institutions. Specific efforts to maintain the quality of the research-based education are also called for.

Capacity-building and expansion of competencies: The renewal of professorships at ETH Zurich and EPFL and of unit/group/laboratory heads at the research institutes is a continuous renewal process allowing redirection of research areas and shifts into new areas. 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, ETH Zurich, EPFL and the research institutes need to increase the number of professors and research groups in the period 2021–2024. Up to 80 additional professorships and research groups will make it possible to guarantee strong links between training and state-of-the-art research, to create new opportunities in research and teaching, and to strengthen already established areas of research and advance into new ones. In addition, this capacity-building and expansion of competencies will enhance the ETH Domains' ability to anticipate and respond to the country's challenges as well as to provide the scientific and technical support for initiatives taken by the respective authorities, e.g. in energy research or digitalisation-related activities.

Strategic focus areas: Strategic Focus Areas (SFAs) address key societal challenges and boost essential 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. For 2021–2024, the three SFAs initiated in the period 2017–2020 – "Personalized Health and Related Technologies", "Data Science", and "Advanced Manufacturing" – will be continued so that their full potential can be realised.

- *SFA Personalized Health and Related Technologies:* in health research, close cooperation of the natural and engineering sciences with medicine has become indispensable for the continued development of "Personalized Health and Related Technologies" at the highest level.
- *SFA Data Science:* this focus area will reinforce and expand Switzerland's capacity to exploit huge data volumes while dealing with them safely. This SFA also reflects the increasing importance of data science for fundamental research.
- *SFA Advanced Manufacturing:* in this focus area, state-of-the-art production processes that can substantially strengthen Switzerland's capacity for innovation and hence also its competitiveness are developed together with industrial partners.

All three SFAs incorporate central aspects of digitalisation in their respective fields. They are also models of successful cooperation among the various institutions and with other partners of the Swiss higher education system such as universities or hospitals. Their research and outreach will put Switzerland in a leadership position in these crucial areas.

Fundamental research as well as state-of-the-art large-scale research infrastructures foster the country's long-term innovative capacity for tackling societal challenges.

Large-scale research infrastructures: The ETH Domain has long-standing expertise and a leading position in planning, implementing and operating large-scale research infrastructures. With specific user and service labs, the institutions provide access to research infrastructures for users from academia and industry. State-of-the-art infrastructures are crucial to ensuring Switzerland's international competitiveness as a centre of research and innovation. In the period 2021–2024, the ETH Domain pursues the following projects of strategic priority:

- the continuation of the “Blue Brain Project” (EPFL),
- “HPCN-24”: substantial upgrade of the current IT infrastructure to build the next-generation supercomputing system that will replace CSCS' current flagship supercomputer “Piz Daint” at the Swiss National Supercomputing Centre (CSCS) of ETH Zurich,
- “SLS 2.0” (major upgrade of the Swiss Light Source SLS at PSI) and
- “Catalysis Hub” (a new research infrastructure co-based at ETH Zurich and EPFL). The development of novel catalytic processes and the use of renewable energy sources such as hydro, solar or wind power to drive chemical reactions are key technologies for the production of fuels, feedstock, fine chemicals and pharmaceuticals and hence for the transition from an oil-based to a sustainable economy. The Catalysis Hub will be crucial to the successful transition of Switzerland and Swiss industry to a sustainable and innovative economy powered by catalysts of the future.

Knowledge and technology transfer: The ETH Domain institutions promote the transfer of its findings and competencies to society and to the economy in diverse ways. They are continuing to expand their position as a key academic partner to private companies and public administration. They are actively involved in the continuing design and implementation of the “Switzerland Innovation” park.

Favourable framework conditions

To continuously fulfil the ETH Domain's mandate in the Swiss societal and political context, it is crucial to ensure favourable operating conditions for the ETH Domain institutions and the Swiss higher education and research system. With respect to the period 2021–2024, the ETH Board:

- sees it as vital that scientists working in Swiss research institutions have access to international networks and international competitive research funding (notably the 9th European Framework Programme for Research and Innovation 2021–2027, “Horizon Europe”, as well as the Euratom research and training programme). For Switzerland to have only a partial association with or even be excluded from the 9th Framework Programme or from Euratom would discriminate against Swiss-based researchers and thus impair Switzerland's scientific excellence.
- believes it is essential to safeguard the three key success factors, i.e. i) internationality and openness, ii) the autonomy of the ETH Domain as a whole and of the ETH Domain institutions, and iii) stable and reliable funding by the Confederation.

Financial requirements 2021–2024

In order to implement the measures, the ETH Board is asking the Federal Council and Parliament to approve CHF 11,053 million as the budget appropriation for the ETH Domain for the period 2021–2024. Based on currently planned federal government funding of the ETH Domain for 2020, the overall requirement for 2021–2024 assumes an annual increase in funding of 3.1% (including compensation for assumed annual inflation of 1%).

Fostering an effective knowledge and technology transfer, providing high-quality scientific services and fulfilling national tasks, the institutions of the ETH Domain create economic value and preserve environmental and public goods.

I. Introduction

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Mission statement of the ETH Domain

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 degrees 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 recognizes the limits to predicting the outcome of research, and therefore supports a broad range of investigator-led activities. It fosters creative individuals and teams driven by their own motivation and curiosity.
- **Knowledge and technology transfer for the benefit of society.** The ETH Domain recognizes its obligation to work for the benefit and well-being of society, to increase national and international prosperity, to create economic value as well as to preserve environmental and public goods. All the ETH Domain institutions foster the uptake of research results into technologies, practice and policy-making to strengthen the productivity, competitiveness and innovative capacity of the Swiss economy. In this way, the ETH Domain responds to the needs of Switzerland, contributes to a sustainable economy and makes its talent available for projects of national priority.

The Federal Act on the Federal Institutes of Technology (ETH Act)

The Federal Act on the Federal Institutes of Technology (ETH Act) of 4 October 1991 defines the status, structure and mission of the ETH Domain (i.e. the six institutions and the ETH Board as the strategic governing and supervisory body). The ETH Act regulates the division of competencies between Parliament, the Federal Council, the ETH Board and the six institutions. According to the legislative provisions, the ETH Domain is autonomous and the ETH Act stipulates that it is affiliated to the responsible federal department. The ETH Act also defines the autonomy of both Federal Institutes of Technology (ETH Zurich, EPFL) and the four research institutes (PSI, WSL, Empa, Eawag).

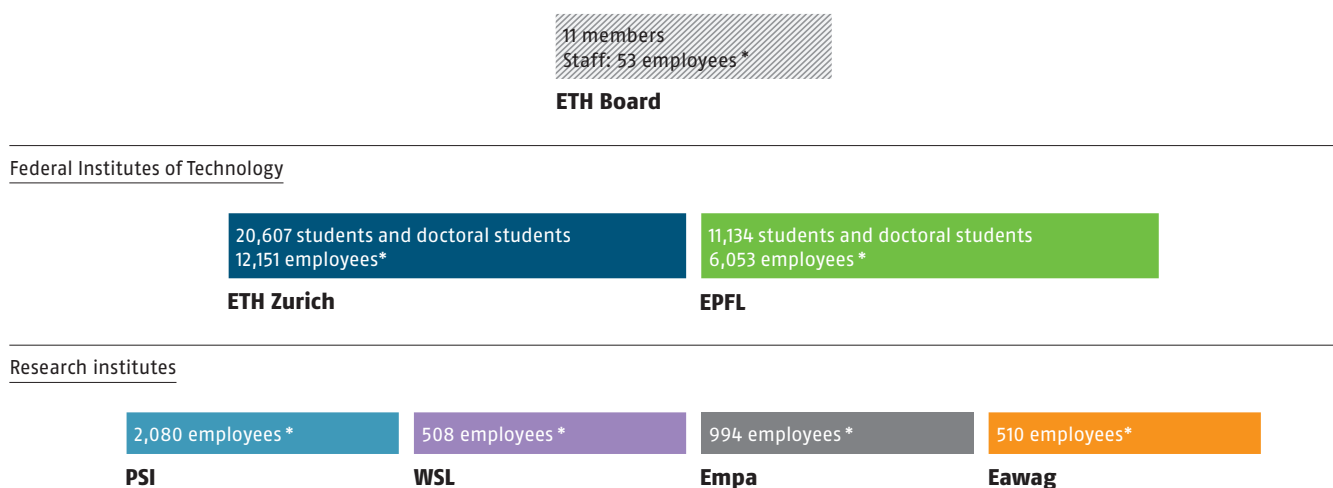
- **Ethical conduct and social responsibility.** The ETH Domain recognizes that scientific integrity underpins all progress in science. In addition, the ETH Domain accepts the responsibility for creating and maintaining work environments that promote diversity and trust. All staff members and students 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.

The ETH Domain in a nutshell

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 supervisory body of the ETH Domain (cf. Figure 1).

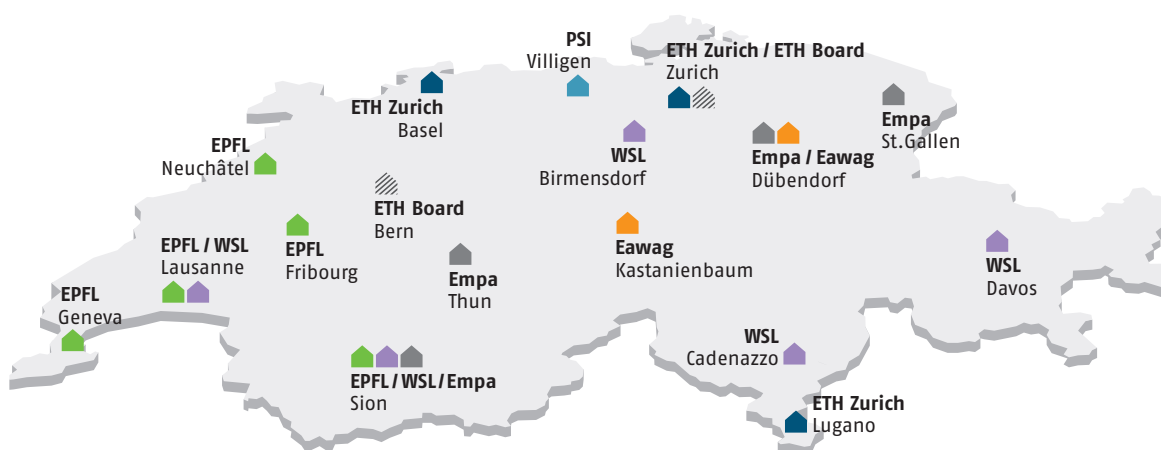
The ETH Domain is firmly anchored in Switzerland (cf. Figure 2) and fulfils its basic mandate according to the principles laid out in the Mission Statement.

Figure 1: The ETH Domain



* Employment contracts (including doctoral students) as of 31 December 2018

Figure 2: The ETH Domain's presence in Switzerland



The unique features of the ETH Domain

The ETH Domain has a number of unique features that allow an excellent positioning of all the six institutions with their distinct profiles. These unique features are thus important internal success factors:

- **The combination of exact, natural and engineering sciences and their link to social science 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 top-level thematic research as well as applied research in their focal areas as well as 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.

ETH Domain personnel policy

The ETH Domain seeks to establish and maintain an inspirational working environment based on the principles of respect, appreciation, equal opportunities, dialogue and trust. Transparent, reliable structures as well as attractive employment and working conditions are designed to motivate employees, help them to maximise their performance and support their professional development.

- **ETH Domain management philosophy:** The ETH Domain recognises that the demands of an academic environment are best met by a participatory style of leadership. Employees must exercise a great deal of personal responsibility, initiative and time management to accomplish tasks that often cannot be fully defined in advance. Supervisors are expected to demonstrate good leadership and management capabilities and to establish a working environment based on respect, appreciation, trust and transparency. Supervisors must be able to deal effectively with conflict situations. Professional HR management is offered to support supervisors in fulfilling these responsibilities and in their capacity as role models and leaders.
- **Diversity:** The international positioning of the ETH Domain institutions depends on their ability to recruit the best talents worldwide, without regard to gender, cultural and social background. Different perspectives and experiences of individual employees bring value to the institution, broaden the experience of students and employees and generate added value in the global competition for talents. The ETH Domain institutions endeavour to provide a working environment that can capture this potential.

International employees are supported in integrating into Swiss society. The ETH Domain recognises the challenges associated with relocation to Switzerland and attempts to support partners accompanying employees in positioning themselves in the Swiss labour market and society.

Gender/Equal opportunities: The ETH Domain institutions promote equal opportunity in all aspects of training and employment. A culture of open communication is promoted and measures are implemented to allow all employees to accommodate their professional and personal commitments (work-life balance). Gender-specific differences are taken into account for career planning. Both female and male employees are offered help to return to work after a period of family leave.

Recruitment includes measures to promote diversity. The ETH Board and the ETH Domain institutions endeavour to achieve a good gender balance, especially in management positions and decision-making bodies.

As a socially responsible employer, the ETH Domain promotes the continued employment and professional reintegration of people with disabilities.

- **Employment and working conditions:** Working in a dynamic academic environment calls for 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 and an ability to engage in dialogue with partners, as well as integrity, respect for and tolerance with employees and supervisors, are further prerequisites for successful collaboration in an international multicultural environment. The ETH Board and the institutions of the ETH Domain promote these values.

Compensation and benefits: The ETH Board and the ETH Domain institutions offer compensation according to their governing regulations. The PUBLICA pension scheme is continually developed to ensure certainty and security in keeping with demographic and socio-economic trends. Tailored solutions are offered to accommodate the ETH Domain's international workforce.

Occupational health and safety at the workplace: To maintain employees' performance, health and well-being, the ETH Domain institutions make continuous investments to improve health and safety at work. Diverse health and safety training programmes are provided for employees.

- **Employee development:** The ETH Domain supports employees in their career development with a range of targeted, needs-based opportunities for professional development. Leadership and management courses support academics and non-academics in the development of social skills and leadership and management competencies.

New scientific talents: To ensure future excellence in teaching and research, it is essential to identify new scientific talents on the basis of their academic credentials, attract them to the ETH Domain institutions and cultivate their scientific potential. Doctoral students and postdoctoral researchers are prepared for successful academic or professional careers.

To promote the next generation of academics, assistant professors are employed both on and off the tenure-track. Increasing the proportion of female professors is an important objective of hiring at this level.

Permanent appointments as senior scientists offer an additional career opportunity. Senior scientists help to ensure continuity and quality by transferring academic knowledge in teaching and research and by operating and developing major research facilities and platforms.

Administrative and technical staff: Highly qualified administrative and technical staff make an important contribution to excellence in research and teaching. These contributions help to secure institutional knowledge and achieve the optimal return on investment in major research infrastructure. The ETH Domain institutions provide opportunities for on-going specialist training to their administrative and technical staff so that they can maintain their performance and development of their competencies throughout their careers.

Trainees: The ETH Domain institutions are fully committed to Switzerland's dual educational system and support it by providing apprenticeship opportunities in a wide variety of specialisations. This also serves to increase the pool of potential applicants for administrative and technical positions.

II. Strategy – Core Tasks and further activities

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Core Task 1: Research-based education of the highest quality

The ETH Domain institutions provide research-based education that is of the highest quality on an international level. The study programmes developed by ETH Zurich and EPFL educate students using systemic and interdisciplinary approaches that are rooted in a profound knowledge of exact and natural sciences and foster an innovative and entrepreneurial spirit. Students are educated to be independent thinkers who will be well equipped to shape the future as responsible members of society. Cooperation with the research institutes of the ETH Domain provides complementary experiences for students at all levels. Innovation in the development of teaching is encouraged and quality is promoted to satisfy the high expectations of students, faculty, staff and society. In addition, the institutions provide expanding options for life-long learning.

Both ETH Zurich and EPFL provide research-based education in the exact and natural sciences, engineering sciences (including computer sciences), architecture and management sciences with links to social sciences and humanities. They offer courses for Bachelor's, Master's and Doctor's degrees and in continuing education that build on solid basic training in mathematics, natural and computer sciences. The four research institutes contribute to course instruction at ETH Zurich and EPFL and provide thesis supervision for students, especially at the doctoral level. The research institutes offer students access to unique facilities and expand their contact with partners in industry and practice and also provide continuing education.

Research-based teaching is the cornerstone of education at ETH Zurich and EPFL. Its focus lies on students learning through enquiry and discovery. Research-based education also means that teaching at ETH Zurich and EPFL is informed by the latest breakthroughs in science and technology, and that students benefit from being involved in the process of knowledge creation. It allows students to carry out research in their courses, which enables them to internalise and practice research methods and skills. It thus contributes to developing essential skills for future leaders and decision-makers, allowing them to innovate, confidently explore new topics and take decisions in situations of uncertainty.

Empowering students to shape their future

"The digital transformation puts all knowledge at our disposal unfiltered – not just high-quality information, but unfortunately unscientific knowledge as well. This means that for teaching at a university to be truly excellent, it must transcend the purely subject-specific dimension. When they go out into the world, graduates need to be not only experts in one particular subject, but scientifically trained young people ready to take their place in their communities. Only then will first-class universities be living up to their responsibility to society"¹.

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 (e.g. communication, teamwork), and to work on complex and system-oriented problems (e.g. major global challenges). In addition to acquiring methodological skills and disciplinary knowledge, they gain the capacity for critical and self-critical thinking as the basis for responsible behaviour and are able to assess the content of their studies from various normative, historical and cultural perspectives.

Study programmes and curriculum development

Societal needs and progress in science and technology constantly drive new developments and create new opportunities. This in turn requires ongoing curriculum development through discussions with faculty, students and industrial partners to meet societal needs and prepare students for new scientific and technological challenges.

At ETH Zurich and EPFL, students are educated using systematic and interdisciplinary approaches that are rooted in a profound knowledge of key disciplines and that foster an innovative and entrepreneurial spirit. The study programmes at ETH Zurich and EPFL, complemented by the option to conduct research for bachelor, master and doctoral theses at the research institutes, are very well suited to the requirements of the job market in Switzerland. They are highly appropriate to the needs of companies, educational institutions, NGOs and public administration in Switzerland and to the Swiss economy as a whole.

The principle of complementarity among the partners in the higher education area is important for the success of the sector as a whole. Thus the ETH Domain institutions must retain a study programme that uses interdisciplinary approaches to solve fundamental scientific problems in their core and emerging research fields. Education in research labs and in international competitive fields helps to develop skills in the management of complex multidisciplinary projects as well as in innovation and entrepreneurship.

¹ Antonio Loprenio (2018) Teaching and innovation. Guest article in: Innovative Teaching, ETH Zurich, pp. 33–37. <https://www.ethz.ch/en/the-eth-zurich/information-material/innovative-lehre.html> (accessed on 18 June 2018)

Core Task 1: Research-based education of the highest quality

The ETH Domain provides world-class, internationally-competitive, research-based education.

Requirements and success factors

- The ETH Domain institutions retain their capacity to shape and continuously develop their curricula – including offerings in continuing education. They must be able to address trends in cutting-edge science as well as the needs of the economy and society. Retaining their autonomy helps the institutions to maintain the required flexibility.
- ETH Zurich and EPFL must retain the ability to attract the most-talented students from around the world and educate them to become independent thinkers who will be equipped to shape the future as responsible experts and members of society.
- Further efforts are needed to ensure that the Matura school-leaving qualification will continue to guarantee that Swiss-educated students have a solid base in mathematics and other STEM disciplines, enabling them to succeed in the competitive environments of ETH Zurich and EPFL.

Challenges

- The ETH Domain fully endorses and supports the current joint efforts to tackle the skills shortage, i.e. specifically the lack of qualified STEM personnel, in Switzerland. Current and future growth in the number of students and doctoral students needs to be accommodated to maintain and further develop the required spectrum and quality of research-based education and training.
- While the primary focus of teaching is the transmission of subject-specific knowledge and interdisciplinary competencies, the digital transformation is adding a new dimension. By offering access to a seemingly endless amount of knowledge, the digital world increasingly requires students to analyse and manage different sources of knowledge. For students to navigate this new situation, research-focused academic institution like those of the ETH Domain are facing the challenge of providing students with knowledge, skills and values that enable them to assess the scientific integrity, value and plausibility of knowledge independently.

- 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.
- The increasing numbers of students calls for major 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 needs to be secured. The integration of international talents in the institutions as well as in Swiss society needs special attention.

Measures 2021–2024

- *Study programmes and curricula development:* ETH Zurich and EPFL further develop existing study programmes and create new ones to educate students using systemic and interdisciplinary approaches that are rooted in a profound knowledge of fundamental disciplines and that foster an innovative and entrepreneurial spirit.
- *Innovation and quality management in teaching:* The ETH Domain institutions provide talented students from around the world with the best possible education to prepare them for their professional careers and their roles in society. The quality of research-based education is maintained and further developed. Teaching methods are continuously improved and new educational formats are offered.
- *Mentoring doctoral students:* The ETH Domain institutions define and promote good mentoring practices; doctoral students and their mentors share responsibility for ensuring productive and rewarding doctoral education and mentoring.
- *Matura school-leaving qualification in mathematics, STEM disciplines and computer science:* The ETH Domain institutions provide training and continuing education for baccalaureate school teachers in the STEM subjects. This will help to ensure that Swiss-educated students with a Matura school-leaving qualification will continue to have a solid grounding in mathematics and other STEM disciplines.
- *Continuing education:* The ETH Domain institutions shape and develop their offering in the area of continuing education, addressing the trends set by cutting-edge science as well as those arising from the economy and society.

Innovation and quality management in teaching

Over the past 20 years, new technologies have significantly changed teaching. Today new educational formats and methods (e.g., MOOCs, flipped classrooms, interdisciplinary projects, Learning Companion) which take student's individual learning styles into account help them prepare for their professional careers and their roles in society. These innovations also provide students with new skills and expertise that are increasingly called for in the working world.

Innovation is an important element in the development of teaching. Improving didactics (deeper understanding, better achievement of learning objectives, greater competence) is central and needs to be focussed on the students. New teaching forms and procedures rely on the innovative strength of faculty and lecturers and are responsive to student feedback. ETH Zurich and EPFL promote these developments and support new teaching forms and procedures with targeted programmes supported by guidance from professional educational developers.

In the spotlight: Computational thinking

Computational thinking is increasingly perceived by educators, policymakers and researchers as a core element of modern education. It is applicable across disciplines beyond science, technology, engineering, and mathematics (STEM) and including the social sciences. The essence of computational thinking is to address problems from any discipline with a coherent process of problem formulation, data representation and the creation of algorithms to produce generic solutions. It includes tools that produce models and visualise data.

At ETH Zurich, the innovative E-Tutorials system allows students to select a level of detail that matches their needs and to practise programming using sample cases. The E-Tutorials project plays a key role in digital skills training at the undergraduate level: it enables over 800 first-year bachelor students from five departments to master the principles of programming. Lecturers from the Department of Computer Science send their students to a virtual programming laboratory, where they solve practical problems from their area of study using real data. In 2018 the project was awarded the KITE award for teaching innovations at ETH Zurich.

EPFL has embarked on a major curriculum reform in which computational thinking will be introduced as a foundation course across science and engineering disciplines, supplemented by the development of disciplinary-specific computational thinking content. In the propaedeutic year, students will learn basic programming skills and be introduced to computational thinking by means of concrete examples. During the rest of their Bachelor and Master studies, courses with disciplinary-specific computational thinking content will be offered. The current courses in statistics, optimisation, numerical analysis and artificial intelligence will be further improved, taking the needs of the individual disciplines into account.

At EPFL, Discovery Learning Labs (DLL) are developed to promote the conceptualisation of basic knowledge through interdisciplinary projects.

The institutions of the ETH Domain promote quality in teaching at all levels in order to satisfy the high expectations of students, faculty and society. Teaching is evaluated on the basis of student semester feedback and student assessments, as well as by graduate surveys and evaluation of ETH Zurich departments or EPFL schools by an international team of experts (peers) in a six- to eight-year cycle.

Horizontal (i.e. geographic) and vertical mobility of students

Successful students in all disciplines have the opportunity to spend one or two semesters at another university in Switzerland or abroad. ETH Zurich and EPFL profit from this transfer of experiences and ideas and also welcome qualified mobility students from Swiss and foreign universities. Since the highly structured Bologna System places limits on semesters spent abroad without a corresponding extension of the study time, ETH Zurich and EPFL do not rely solely on horizontal mobility. Rather, they create a thematically diverse and international environment, which promotes intellectual flexibility as well as understanding and respect for other cultures. Students are thus exposed to international competition and cooperation in their familiar teaching environment.

ETH Zurich and EPFL support student transfer from Universities of Applied Sciences (vertical mobility). Appropriate transfer regulations avoid any compromise in the profile, level or quality of their master's degree courses.

Doctoral training and mentoring

Doctoral students at ETH Zurich and EPFL are required to work on an independent scientific thesis and to take the initiative in pursuing continuing specialist and interdisciplinary development. Thesis research is usually undertaken as a member of a research group at the doctoral student's home institution or at one of the ETH Domain's four research institutes. Doctoral qualifications are earned either under an individually customised study programme or a doctoral programme, or within a doctoral school. Doctoral students have the opportunity to acquire additional skills by assisting in teaching. They thus acquire a valuable additional qualification (for example didactic skills) and expand their set of competencies for subsequent professional roles. As members of well-connected research groups, doctoral students also enjoy access to the international research community and can begin to build up their own scientific network.

Mentoring by faculty plays a crucial role in the success of doctoral students, and the importance of mentoring is emphasised within the ETH Domain. Styles of advising and mentoring vary across the disciplines and according to personal inclination, but some fundamental principles apply throughout doctoral education. Both doctoral students and their mentors share responsibility for ensuring productive and rewarding mentoring.

Training and continuing development of lecturers, assistants and baccalaureate school teachers

ETH Zurich and EPFL offer their lecturers and assistants a broad didactic training and continuing development programme and provide professional support in the creation and introduction of new teaching and learning forms.

Both ETH Zurich and EPFL are highly aware of the importance of high-quality teaching at baccalaureate schools that foster strong mathematics skills and an appreciation of natural sciences and technology. This preparation largely determines the success of students entering ETH Zurich and EPFL. By providing training and continuing education for baccalaureate school teachers in the STEM (science, technology, engineering, and mathematics)

subjects, the institutions of the ETH Domain make an investment in their future students and contribute to knowledge transfer.

Continuing education

Continuing education is an effective instrument for the transfer of knowledge and technology between academia and society at large. Through their continuing education programmes, the ETH Domain institutions contribute to the long-term development of society and the economy and help strengthen the competitiveness of Switzerland as a business location. A wide range of practice-oriented courses are offered on topics that reflect the respective institutional core areas and that combine technology with management and social sciences. Continuing education courses take account of the participants' individual needs and prior knowledge and give them the opportunity to build up their specialist and personal networks. Often, these courses are developed in close cooperation with professional associations, groups of companies or other universities. Such courses provide valuable life-long learning opportunities for the practitioners who are responsible for promoting innovation within industry and society or for the commercialisation of scientific findings.

Projections of numbers of students, doctoral students and professors for 2021–2024

Addressing the needs and creating new opportunities in research and teaching

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. In order to remain a driving force in contributing to Switzerland and its innovative capacity and to maintain their international reputation for excellence, both ETH Zurich and EPFL intend to invest more in talents and student supervision. Increasing the number of professors is necessary to sustain high quality in research-based education and will also create new teaching opportunities. Accommodating the estimated student growth for the period 2021–2024 would require increasing the number of professorships to around 600 (+50) by 2024 at ETH Zurich and to around 360 (+30) by 2024 at EPFL, including adjunct professors appointed at the research institutes.

ETH Zurich: In the period 2021–2024 the number of students and doctoral students is estimated to increase by 4 % to 22,300 (basis 2020). This corresponds to a 2 % rise in student numbers to 17,500 and a 9 % increase in doctoral students to 4,800 by 2024.

EPFL: For the period 2021–2024 the number of students and doctoral students is estimated to increase by 3 % to almost 11,600 (basis 2020). This corresponds to a 3 % rise in student numbers to 9,100 and a 5 % increase in doctoral students to almost 2,500 by 2024.

Core Task 2: World-class research

The ETH Domain institutions perform research at 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 groundbreaking innovation and is therefore crucial for fostering the country's innovative capacity in the long term. International collaboration in research projects is of growing importance and key for the quality of science and research in the ETH Domain. As part of their mission, the six institutions anticipate and respond to the country's challenges.

As demonstrated by academic indicators (e.g. rankings, bibliometric analyses) and by the regular evaluations of individual institutions and units thereof, the ETH Domain institutions perform research at a world-class level.

Long-term fundamental research

The goal of fundamental research is to generate new knowledge. This knowledge in turn is essential to further scientific work and provides the starting point for innovations. ETH Zurich and EPFL carry out fundamental research of the highest quality. Since fundamental advances in science are inherently unpredictable and often take many years, the institutions provide their researchers with sufficient scope and resources for exploratory long-term research. Major scientific and technological breakthroughs often come about as a result of fundamental scientific findings made much earlier. Investing in fundamental research is thus an investment in future innovations. This innovation pipeline must be maintained and cannot be substituted by R&D in industry.

Besides fundamental research, the institutions of the ETH Domain conduct applied research, which frequently means first establishing fundamental and methodological knowledge. Fundamental research and applied research go hand in hand within the ETH Domain. They stimulate each other, and are often carried out together with academic partners as well as partners from industry and the public sector.

International collaboration

International collaboration is crucial for the quality of science and research at the ETH Domain institutions and research infrastructure (see also Core Task 3). Working with scientists outside Switzerland provides access to valuable additional expertise. It also opens up 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 achieve greater impact. 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, to obtain access to major research infrastructures worldwide and to participate in international networks.

In the spotlight: The Singapore-ETH Centre

The Singapore-ETH Centre for Global Environmental Sustainability (SEC) in Singapore was established in 2010 as a collaboration between ETH Zurich and the National Research Foundation of Singapore as part of its CREATE campus. The SEC aims to strengthen the capacity of Singapore and Switzerland to research, understand and actively respond to the challenges of global environmental sustainability through its programmes – Future Cities Laboratory and Future Resilient Systems.

Promotion of young academics, doctoral students and postdocs

The ETH Domain institutions must maintain and further develop their ability to attract (young) academics from Switzerland, Europe and around the world and to offer them attractive development opportunities both within and outside academia. This calls for a continuation of current strategies to develop the skills of young academics ("talent promotion"). As excellence attracts excellence, Switzerland as a scientific and an economic location, as well as young Swiss academics themselves, benefit from this approach.

In addition to established scientists, doctoral students and postdocs also play a key role in research. They are crucial to promoting the international reputation of the ETH Domain institutions in the science community. When selecting doctoral and postdoctoral candidates, all institutions in the ETH Domain give top priority to academic achievements and scientific potential.

The institutions offer doctoral students and postdocs attractive employment conditions as well as intellectually challenging and stimulating research environments. Where necessary, the ETH Domain institutions will optimise support and career advancement opportunities under both research group-centred doctorates and the structured doctoral programmes.

The six institutions provide doctoral students and postdocs with an environment (e.g. research infrastructures, libraries, discussion forums) that meets the highest international standards.

Core Task 2: World-class research

The ETH Domain institutions further extend their globally leading positions in research.

Requirements and success factors

- To realise their research strategies and to be able to invest in fundamental and long-term-oriented research, it is of crucial importance that the ETH Domain institutions can continue to autonomously allocate and manage their global budgets.
- 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.
- The ETH Domain institutions must maintain and further develop their ability to attract (young) academics from Switzerland, Europe and around the world and to offer them attractive development opportunities both within and outside academia.
- The full association of Switzerland with the 9th EU Framework Programme for Research and Innovation – Horizon Europe 2021–2027 – is a key success factor for Switzerland's innovative capacity and for the Swiss science community.
- Adhering to good scientific practice and respecting the principles of research integrity are prerequisites for excellent science.
- Subsidiary, bottom-up organisation of research, setting of research priorities, and budgeting of resources that allows for the recruitment and retention of talents.

Challenges

- It is vital that scientists working in Swiss research institutions 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 programme). For Switzerland to have only a partial association with or even be excluded from the Framework or Euratom programmes would discriminate against Swiss-based researchers and thus impair Switzerland's scientific excellence.
- 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.
- 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.
- To be able to develop new research fields and meet teaching needs, to continue making a vital contribution to Switzerland and its innovative capacity, to address urgent societal challenges and to maintain their international

reputation for excellence, both ETH Zurich and EPFL need to constantly review and re-direct the scope of professorships and to increase their number of professorships.

Measures for 2021–2024

- *Long-term fundamental research*: the ETH Domain institutions provide their researchers with sufficient scope and resources to conduct exploratory fundamental research over the long term.
- *Capacity-building*: in order to engage in new fields of research and teaching, ETH Zurich, EPFL and the research institutes will redirect existing professorships and increase the number of professors and research groups according to the available budget.
- *Attracting national and international talents*: the ETH Domain institutions are attractive for talented students and academics from Switzerland, Europe and around the world and offer them attractive employment conditions as well as intellectually challenging and stimulating research environments.
- *Addressing societal challenges*: the ETH Domain institutions contribute to tackling current and future national and global societal challenges. To increase impact, existing expertise in the ETH Domain is thematically focused and new or recently established initiatives of the institutions are given coordinated support (e.g. as Strategic Focus Areas).
- *International cooperation and networks*: the ETH Domain institutions autonomously participate in international cooperations and networks. In line with the Federal Council's international strategy on Education, Research and Innovation, the institutions play an active role in research cooperation ventures with priority countries (e.g. serving as the "leading house") and operate international subsidiaries.
- *Research integrity and responsibility*: the ETH Domain institutions create an environment designed to promote respect for, and compliance with, the ethical principles and values for ethical issues in research and science, in good scientific practice and in responsible mentoring and fair awarding. They continuously sensitise their employees and students to these requirements. The institutions issue directives on research integrity and good scientific practice and ensure that these are made known to all members of the institution by appropriate education and training.

As a result, the institutions ensure that their doctoral students and postdocs are optimally prepared for a future career in the global labour market in science, business, public administration or academia. Doctoral students also have the option of completing a doctoral thesis at one of the research institutes of the ETH Domain in cooperation with one of the Federal Institutes of Technology or another degree-granting university. Since such thesis projects are frequently carried out with an implementation partner, doctoral students can gain hands-on experience and additional skills.

Academic freedom and ethical responsibility

Freedom of research is a central and fundamental value of academic research. Freedom in the choice, development and realisation of research topics and in the publication of research results is essential to the impartial pursuit of knowledge for the good of the economy and society. This is the basis for the international standing and competitiveness of researchers in the ETH Domain. The ETH Board and the executive boards/directorships of the institutions recognise that successful research is motivated from the bottom up, reflecting and taking

advantage of the interests, curiosity and enthusiasm of members of the research community. A flourishing scientific community and research promotion can only be built on trust. The freedom given to science and research by society and politicians calls for researchers to accept the principle of, and the values associated with, research integrity as well as a sense of ethical responsibility towards science, society and the environment. Research integrity and good scientific practice therefore have the utmost priority for the ETH Domain institutions. The institutions create an environment designed to promote respect for and compliance with the principle of, and the values associated with, research integrity and good scientific practice as well as the assumption of ethical accountability. The institutions have issued directives on search integrity and good scientific practice and on measures to address violations. They ensure that such directives are kept up-to-date and made known to all members of the institution.

Addressing societal challenges

As the main federal institutions for research, education and innovation, the ETH Domain institutions have a unique position in the Swiss academic landscape. Their mission includes anti-

In the spotlight: The ETH Domain – a major force for the digital transformation of Switzerland

The ongoing digital transformation is an opportunity for Switzerland to strengthen its general welfare and worldwide economic and reputational position by setting trends and developing innovative products and applications. In a highly interconnected world, the global infrastructure faces many challenges and threats that are beyond the control of a single nation. A key challenge in digitalisation is that technology has outrun and eroded existing trust models. The recent emergence of decentralised ledger systems (i.e., blockchains) raises the possibility that currencies, insurance, land registries and even voting can be distributed, changing and reconfiguring the trust placed in centralised institutions and private entities. Switzerland must take a leading role in this digital transformation, not 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. Therefore, Switzerland too should seize this opportunity and have the ambition to be a leader in developing and shaping the next stage of the digitalisation of the economy and society.

The leading role of the ETH Domain in digitalisation

Switzerland has a leading international position in core technologies such as cryptography, blockchain, security and cybersecurity due to long-term investments by the ETH Domain institutions and traditionally by Swiss industry. These institutions are well positioned on an international scale to significantly support the digital transformation of Switzerland. Their excellent reputations are reflected in their top positions in various university rankings. The ETH Domain institutions collectively not only have a long tradition of world-class research and teaching in the foundational areas of

digitalisation, but they also are actively applying the technology to areas of societal interest. Besides individual efforts, the institutions are closely cooperating in joint and coordinated research and technology transfer activities and are working closely with society, government and industry on many aspects of the challenges that digitalisation poses for society. This collaboration involves all the various strata of the institutions, including administration, scientific personnel, group leaders and professors.

Digitalisation-related activities of the ETH Domain 2021–2024

Appropriate measures are necessary in order to retain or even expand the traditional strengths of the Swiss economy and society as digitalisation reshapes virtually all aspects of our society. Based on an analysis of the current situation in research, education and transfer to society, industry and government, the following six areas exhibit a substantial need for a joint effort. Some of these areas can be addressed in close collaboration between the ETH Domain institutions and industrial partners, for example in wireless technologies, the Internet of Things, artificial intelligence, machine learning, and high volume data management. Owing in particular to their large scale research infrastructure, the research institutes may act as a challenging test environment for new technologies and concepts in data processing and management which can later be used by industry.

– *Capacity building and expansion of competencies:* Both ETH Zurich and EPFL have been expanding their activities for many years in areas of strategic importance. Accordingly, a significant number of professorships has been thematically oriented towards strategically important topics and a significant number of new professorships has been established in the past, particularly in the area of ICT/computer science. Under the Federal Action Plan on Digi-

pating and responding to the country's challenges, as well as providing the scientific and technical basis to support the initiatives of its authorities.

To enable Switzerland to acquire the necessary know-how in pioneering fields of research that are increasingly relevant to society, economy and the environment, and to boost its competitiveness, the ETH Domain has identified Strategic Focus Areas (SFAs) for targeted funding. These address key societal challenges and boost essential 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.

The three SFAs "Personalized Health and Related Technologies (PHRT)", "Data Science", and "Advanced Manufacturing" initiated in the period 2017–2020 will be continued during the period 2021–2024 in order to realise their full potential.

- *SFA Personalized Health and Related Technologies (PHRT)*: in health research, close cooperation between the natural and engineering sciences on the one hand and medicine

on the other has become indispensable for the continued development of Personalized Health and Related Technologies at the highest level.

- *SFA Data Science*: this Focus Area will reinforce and expand Switzerland's capacity to exploit huge data volumes while dealing with them safely. This SFA also reflects the increasing importance of data science for fundamental research.
- *SFA Advanced Manufacturing*: in this Focus Area, state-of-the-art production processes that can substantially strengthen Switzerland's capacity for innovation and hence also its competitiveness are developed together with industrial partners.

All three SFAs incorporate central aspects of digitalisation in their respective fields. They are also (or will be) models of successful cooperation among the various institutions and with other partners of the Swiss higher education system, such as universities or hospitals. Their research and outreach will put Switzerland in a leadership position in these crucial areas.

talisation, ETH Zurich and EPFL have intensified and expanded their ongoing efforts to increase the number of professorships in ICT/computer science and have established additional seven new professorships, four at ETH Zurich and three at EPFL. Switzerland's scientific and innovative capacity in the fields underpinning digitalisation and cyber technologies will be increased by the ETH Domain institutions through further investments in joint efforts and capacity-building.

- *Education*: Continuous efforts are necessary to establish high-quality education programmes in areas that are relevant to the digital society on all levels. The existing expertise of the ETH Domain institutions will be expanded and new study programs will be set up. The goals should be to offer high-quality continuing education programmes for people in the labour force, courses to aid industrial rehabilitation, and support for education in computer science, programming and computational thinking at all school levels, from primary school up to baccalaureate schools. Teacher training is a primary concern, in conjunction with the development of new teaching materials as well as novel approaches to science and technology education. The corresponding political processes and close integration with efforts at the universities, the Universities of Applied Science and the Swiss Conference of Cantonal Ministers of Education (EDK) will be crucial for success.
- *Cyberphysical systems and Internet of Things*: Cyberphysical systems and the Internet of Things comprise the observation of environmental, biological, financial or industrial processes using sensors, the extraction of information and knowledge from the collected data, and the influencing of these processes via autonomous decisions. It is widely held that this area will drive the next wave of digitalisation. Despite many excellent efforts in this area, a critical mass of research across Switzerland still needs to be reached to compete with other nation-scale efforts.

- *Cybersecurity*: Switzerland needs to be at the forefront of cybersecurity technology to maintain and expand its industrial position, particularly in finance. Institutions in the ETH Domain play a leading international role already, but they need to expand their existing capacity in cybersecurity, privacy and digital trust education as well as research and knowledge transfer to reflect their vastly increasing importance in society, industry and politics. The ETH Domain should also exploit its foundational strength in software engineering and formal-methods research to launch a new programme to develop a Swiss-verified software industry. This new programme on verified software will address a fundamental cyber-security 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 to move from being a consumer of software to a major producer of high-value software products.

- In addition, the ETH Domain should be an integral part of the intended Cyberdefence (CYD) Campus and play a crucial role in technological monitoring and risk assessment. Successful blueprints of such a programme can be found in other countries such as Israel, where they also yield large benefits for research, start-ups, and the security of national infrastructure.

- *Digital Society*: Digitalisation will raise new questions in classically regulated areas such as security and privacy, freedom of information, protection of property, and responsibility of autonomic systems. These questions pose difficult legal, ethical, and political challenges. Beyond the currently existing individual efforts, the ETH Domain institutions are well-positioned to jointly take on the challenges as part of an interdisciplinary effort to understand and manage these challenges for the good of society.

Strategic Focus Area Personalized Health and Related Technologies (PHRT)

Context and scientific rationale

Advances in the life sciences and information technology (IT) 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 collected by individuals themselves. 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 focusses on individual patients, so-called "personalised health" (PH) aims at using 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, for reasons of societal importance and economic potential.

Making PM/PH programmes possible requires a high level of innovative science and technology as well as sustained intensive collaboration between natural sciences, engineering, data science – and, of course, medicine. In this realm, the ETH Domain institutions are well positioned to make significant contributions, specifically through the development of new technologies that, for example, determine the precise molecular makeup of patients, the translation of innovative technologies into clinically relevant platforms or devices and the development and application of sensors that determine the phenotypic state of persons, and also through the training of clinical scientists and practitioners. In combining and necessarily requiring the various disciplines mentioned above, PM/PH reveals its outstanding position for harvesting the unique potential of the ETH Domain's interdisciplinary setup.

What SFA PHRT is about

The overarching goal of PHRT is to establish and sustain the ETH Domain in a worldwide leading position in PM/PH: in essence, a person's unique biological makeup will guide decisions on how to maintain and restore health.

The PHRT initiative is complementary to and operates in close cooperation with the efforts undertaken by other initiatives in Switzerland, in particular the Swiss Data Science Center (SDSC), and the Swiss Personalized Health Network (SPHN). In addition, it is linked to international research efforts, including The Cancer Genome Atlas (TCGA) and the Cancer Moonshot initiative, both at the National Institutes of Health (NIH, USA).

Benefits for science and society

PHRT aims to foster the development, implementation of PM/PH-relevant technologies and their translation to clinical practice. This is achieved in close cooperation with the SDSC. The establishment of close collaborations between ETH Domain institutions and different types of hospitals is essential for the translation into practice of PHRT technologies and for generating benefits from the cooperation with SPHN, particularly for the definition and implementation of ethical and legal policies. Achievement of the PHRT goals will lead to a healthier society by preventing the onset of disease, providing the precise molecular diagnosis of disease and facilitating the selection of the optimal drug or radiation-based "precision" treatment when disease occurs, or through behavioural changes that prevent the onset of disease. In addition to the direct benefits to the population's health, the programme will advance society through the development of new technologies and knowledge that will form the basis for new economic activities, the generation of intellectual property and the definition of healthier lifestyles.

Current state of implementation

During the 2017–2020 period, four programmes (an educational programme on the doctoral and postdoc level; translational technology projects; technology platforms; personalised health research projects with direct relevance for the patient) are being set up 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 and (c) develop infrastructure platforms.

Activities 2021–2024

The extension of the PHRT through the 2021–2024 period will make it possible to (i) consolidate and implement achievements of the first phase and, in particular, to achieve closer collaboration within the ETH Domain and institutions outside the ETH Domain playing a critical role in personalised health; (ii) initiate interactions of, for example, different technological platforms, or with the SDSC; and (iii) set up next-generation platforms emerging from the innovative ETH Domain technologies developed to full maturity in the first phase of the initiative.

www.sfa-phrt.ch

Strategic Focus Area Data Science

Context and scientific rationale

The “fourth industrial revolution” is driven by the convergence of smart, connected systems with breakthroughs in areas ranging from gene sequencing to nanotechnologies. In this new era where data is the “new oil”, crude data is of little value. But if this data can be extracted and then refined and supplied to where it can impact decisions its value will soar.

Data science is the new research paradigm concerned with executing this vision. It 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 (among others) for understanding and influencing complex, real-world systems and for tackling some of the most challenging problems of our time.

Unfortunately, as things stand today, the available data and analytics methods and systems are highly fragmented. They are difficult to use for non-experts and the results are often very difficult to interpret. In other words, there is a gap between those who create data, those who develop data analytics and systems, and those who could potentially extract value from it. This gap is deepened by the inherent sensitivity of much data: trust through legal compliance, privacy preservation and secure storage and processing are essential for exploiting the full potential of data science.

In the past few years, data science has become extremely important internationally, with the majority of top-tier international research and teaching institutions investing significantly in dedicated centres and programmes.

What SFA Data Science is about

The ETH Domain has launched the Initiative for Data Science in Switzerland to accelerate data science through education and research and the provision of infrastructure. The Initiative created the Swiss Data Science Center (SDSC), a joint venture between EPFL and ETH Zurich whose mission is to accelerate the use of data science and machine learning techniques broadly within academic disciplines of the ETH Domain, the Swiss academic community at large and industry.

The vision is to unlock actionable insights from diverse sources of data. The SDSC aims to federate data providers, data and computer scientists and subject-matter experts around a cutting-edge analytics platform offering domain-specific “insights as a service” while addressing security and privacy issues inherent to the field of data science. Rather than building its own infrastructure, the online services of the SDSC are backed by existing infrastructures of the ETH Domain (in particular by leveraging resources at the Swiss National Supercomputing Centre CSCS), SWITCH, as well as those of cloud providers.

Digital technologies and health care

Digital technologies fundamentally shape the future of healthcare. They offer patients convenient access to therapies and interaction with medical professionals. Moreover, pharmaceutical companies, physicians and health insurance firms gain access to valuable data, increasing drug development effectiveness, individualising treatments and assisting patients during therapy. Yet, considerable uncertainty exists as to how health can be enhanced by optimally leveraging these new opportunities, and as to what effects digital applications such as machine learning in drug discovery or the MobileCoach have on designing therapies and treatments.

Benefits for science and society

The SFA Data Science fosters collaboration with top institutions and entails exchanging best practices in curriculum development and joint data science research projects, thus advancing the state-of-the-art in data science. It will ensure that the ETH Domain and Switzerland possess the necessary expertise to remain globally competitive.

The unique synergy that the SFA Data Science unlocks among the institutions of the ETH Domain and between academic and industrial stakeholders in data science, as well as across a number of carefully selected areas, is expected to foster scientific breakthroughs with significant societal impact.

Current state of implementation

The SDSC has been fully operational since January 2017, with offices at EPFL and at ETH Zurich. The SDSC set up is well on track with the launch of the SDSC analytics platform, with the successful first call for Data Science projects, and with ongoing academic and industrial collaborations. The second call for proposals was launched in May 2018. The SDSC is also part of EPFL and ETH Zurich teaching programs.

Activities 2021–2024

In the period 2021–2024, the SFA Data Science will:

- extend the adoption of the SDSC platform to national and international academic institutions and to industry;
- accelerate the adoption of data science by industry through collaborative research;
- contribute to the education and dissemination of knowledge in data science.

www.datascience.ch

Strategic Focus Area Advanced Manufacturing (AM)

Context and scientific rationale

Industry is a key factor for wealth and prosperity and generates 28 % of the GDP in Switzerland. It is a catalyst for progress and a driver for our future. The world of manufacturing is undergoing rapid change due to the higher level of digital control, which is in turn driving radical innovations in the ways products are designed, manufactured and used.

The development of such new technologies, as well as their transfer and introduction into an industrial application, is often challenging and requires competencies and expertise across 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 international scientific and technical community is developing advanced manufacturing technologies using the potential of today's very powerful digital technologies. Swiss industry must keep pace with these changes, often described as the so-called fourth industrial revolution, and it must strive for a leading position at the cutting edge of these novel technologies. The institutions of the ETH Domain, in particular ETH Zurich, EPFL, Empa and PSI, are predestined to take a leading role in developing such novel technologies.

What SFA AM 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 will encourage the ETH Domain institutions to team up with further scientific and industrial partners, collaborate in exploratory research projects, and build the knowledge and infrastructure needed to position Switzerland as a leader in this field. The programme of the SFA AM includes funds for research projects as well as for capacity build-up and technology platforms. Both areas include translational activities and contribute to technology and knowledge transfer into Swiss industry.

Benefits for science and society

The SFA AM benefits industry in Switzerland 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, the SFA AM will thereby help Swiss industry to maintain its capacity for the local production of high value-added goods, and its strength as an exporter of innovative production processes and machines.

Current state of implementation

Advanced Manufacturing is a very broad technical field. The participating ETH Domain institutions defined five Technical Focus Areas (TFA) – Precision Free Form Manufacturing, Printed Electronics, Sustainable Digital Manufacturing and Design, Sensing Technologies, and Intelligent Systems and Advanced Automation – for which exploratory research projects and the build-up of infrastructure have been launched. These TFA are highly relevant to Switzerland's economy and in line with the involved ETH Domain institutions' strategies for the future.

Activities 2021-2024

The SFA AM aims to cover a broader scope in Advanced Manufacturing by integrating the infrastructure that has been developed in the period 2017-2020 and by adding further and complementary Technical Focus Areas, in particular those most heavily impacted by a higher level of digitalisation and where there are great opportunities for new technologies and innovations that are relevant to Switzerland.

At the same time, the research activities, the capacity-building, the technology platforms and the educational activities of the SFA AM will raise young engineers' awareness of the topic of Advanced Manufacturing and be conducive to their education in this field and associated aspects of materials science.

This will help the ETH Domain to maintain its excellent position and international reputation in engineering education and will additionally benefit Swiss industry, as employers of these engineers, to master the new challenges of this fourth industrial revolution.

www.sfa-am.ch

In the spotlight: Continuing activities of the ETH Domain in energy research

The Swiss Energy Strategy 2050 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 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. Within the ETH Domain, research questions are addressed in a multidisciplinary way which cannot be provided by industry.

Under 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 profited from this both directly and indirectly. For the period 2017–2020, the ETH Board decided to group together the ETH Domain’s broader energy research activities in the “Energy” SFA and allocated a total of CHF 60m to the base budgets of the participating institutions. 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.

Areas of work include energy-efficiency, smart networks, harvesting and storage of energy from renewables (ETH Zurich, EPFL, Empa), chemicals and hydropower (EPFL, PSI, ETH Zurich), as well as catalysis (ETH Zurich, EPFL, PSI) and catalytic biomass conversion (PSI, EPFL). ETH Zurich launched a cross-departmental initiative for an integrated Energy System Modelling Platform (Nexus). Furthermore, an Energy System Integration Platform (ESI) 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) and “move, Empa’s Future Mobility Demonstrator” as well as the Smart Living Lab (EPFL Fribourg).

Among other things, Empa stepped up interdisciplinary research into thin-film solar cells with a strong focus on electrodes and manufacturing processes; some of the funds were used for the joint venture between EPFL and Empa on the “Laboratoire des matériaux pour les énergies renouvelables” (LMER) at the EPFL campus in Sion. In the Energy Change Impact research programme, WSL and Eawag joined forces to investigate the environmental and societal impacts of the intended energy transition and hence the related 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 research, 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).

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 production. Furthermore, PSI implemented the Swiss Center of Excellence for Nuclear Energy and Safety, which provides scientific support to the Swiss nuclear regulatory authority and industry, and hosts the sole Swiss “hot laboratory” with its unique infrastructure for the investigation of highly radioactive materials. 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. ETH Zurich, EPFL and PSI are successfully training engineers within their joint Master’s programme in Nuclear Engineering and make an important contribution to the retention of nuclear competencies in Switzerland. In parallel, the ETH Zurich Master’s programme in Energy Science and Technology and the new Master’s in Integrated Building Systems continue to contribute to the education of engineers and architects in the energy domain.

Core Task 3: State-of-the-art large-scale research infrastructures

The ETH Domain's portfolio of large-scale research infrastructures is especially important for ensuring innovative, solution-focused advancement of cutting-edge research in Switzerland and elsewhere. The institutions operate and maintain state-of-the-art research infrastructures, many of which are available as user facilities to support research nationally and internationally. The ETH Board coordinates planning and provides funding for the further development of such infrastructures and the research associated with them.

Large-scale research infrastructures link excellence in science, technology and education. These infrastructures offer unique opportunities for the education and training of young scientists. Countries that host large-scale national research infrastructures have a distinct competitive advantage in accessing international large-scale research infrastructures abroad. Swiss researchers have a proven track record of being highly successful at international infrastructures, such as CERN at Geneva, the Institute Laue-Langevin (ILL) and the European Synchrotron Radiation Facility (ESRF), both at Grenoble, France – to give a few examples.

The development of large research infrastructures boosts technology transfer through intensified collaboration with industry partners during the development and construction phases and through spin-offs. Furthermore, research infrastructures have a direct market impact in several areas: as suppliers of cutting-edge research, as buyers and co-developers of high-tech products and high-end services, as providers of scientific advice, and as sellers of state-of-the-art services both to academia and to industry.

The leading role of the ETH Domain

According to the Strategic Goals of the Federal Council for the ETH Domain as well as the "Swiss Roadmap for Research Infrastructures", the ETH Domain has a specific responsibility to develop new and improve existing research infrastructures of national importance, thereby ensuring open access for research communities. It is through the ETH Domain institutions that the Confederation puts world-class research infrastructures at the disposal of the scientific community in Switzerland. Therefore, most of the large-scale research infrastructures of the ETH Domain are operated as User labs and are coordinated through the Swiss Roadmap process.

The institutions of the ETH Domain 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 3), but also contribute decisively to the development of such infrastructures within international consortia. In such endeavours (e.g. European Spallation Source ESS, ITER, Large Hadron Collider LHC, European XFEL), 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.

Efforts to continuously upgrade the instrumentation together with the development of new infrastructures guarantee state-of-the-art research opportunities for the national and international research community and ensure that the ETH Domain institutions will remain trendsetters in the coming years.

Figure 3: Examples of large-scale research infrastructures in the ETH Domain

Full name (acronym)	Lead institution(s)
Swiss National Supercomputing Centre (CSCS)	ETH Zurich
Blue Brain Project (BBP)	EPFL
Swiss Plasma Center (SPC)	EPFL
Swiss Data Science Center (SDSC)	EPFL/ETH Zurich
X-Ray Free-Electron Laser (SwissFEL)	PSI
Swiss Light Source (SLS)	PSI
Swiss Spallation Neutron Source (SINQ)	PSI
Swiss Muon Source (SμS)	PSI
Next Evolution in Sustainable Building Technologies (NEST)	Empa/Eawag

Core Task 3: State-of-the-art large-scale research infrastructures

The ETH Domain operates and develops large-scale research infrastructures of national and international significance.

Requirements and success factors

- The institutions must be enabled to guarantee *continuous reinvestment to keep the existing large-scale facilities competitive at the international level* and to allow scientific agenda-setting in strategically important areas by acquiring or designing new large-scale research infrastructures.
- *Coordination on the national level* through the Roadmap process – including among ETH Domain institutions – must ensure that existing strengths are most effectively used and are well balanced against the autonomy of the institutions to set their academic and infrastructural priorities.
- Protecting *internationality and academic openness* is a core requirement for the ETH Domain's role and contributions regarding large-scale research infrastructures in particular.
- Open and transparent *access for researchers worldwide* should continue to be granted, a principle which has always been applied in a reciprocal manner, benefiting Swiss researchers at infrastructures abroad as well.
- Additional success factors are the possibility to contribute under international law to research infrastructure projects abroad (e.g. through in-kind contributions); the possibility to join ERIC (European Research Infrastructure Consortia) as a full partner; and the exchange of staff between research facilities.

Challenges

- The current and planned large-scale research infrastructures of national importance based in the ETH Domain need to be financed, operated and periodically upgraded in a way that guarantees academia and industry access to these state-of-the-art infrastructures.
- Given the complexity and the increasing costs for the design, construction and operation of new large-scale research infrastructure projects of international importance, such endeavours require increasingly international consortia and transnational funding.

Measures for 2021–2024

- *Open access to large-scale research infrastructures*: the ETH Domain operates, develops and builds large-scale research infrastructures of national and international importance which they make available, for example in the form of user labs, to the scientific community and – in return for adequate compensation – to industry too.
- *Strategic initiatives*: The ETH Board gives strategic priority to the following projects: the continuation of the Blue Brain Project (BBP), the upgrades of the computing infrastructures (HPCN-24) at the CSCS and the Swiss Light Source (SLS 2.0), and the realisation of the Catalysis Hub as a contribution to catalysis-driven, sustainable chemical processes (incl. provision of fuels and feedstock for a green economy).
- *Contributions to international research infrastructures*: the ETH Domain institutions autonomously participate in or contribute to international consortia for the realisation of large-scale research infrastructures.

Strategic initiatives for 2021–2024

For the period 2021–2024, four research infrastructure projects have strategic priority for the ETH Domain:

- *Blue Brain Project (BBP)*: Since its inception in 2005, the Blue Brain Project (BBP) at EPFL has pioneered the new field of simulation neuroscience and has developed a unique world-leading simulation-based platform that enables neuroscience to leverage mathematical, computer and computational sciences to advance our fundamental understanding of the brain. The aim of the BBP is to build accurate, biologically-detailed digital reconstructions and simulations of the rodent, and ultimately the human brain, and to use simulation to probe and understand the chains of events responsible for the brain's emergent behaviour at different levels of organisation, up to and including cognition. The BBP created the first large-scale science collaboration in neuroscience, namely the European Human Brain Project (HBP) – one of the first two European Commission-funded Future Emergent Technology (FET) Flagship Projects, which in turn triggered a world-wide race for large national-scale brain initiatives.

For the 2021–2024 period, the scientific goal of the BBP is to implement strategies and tools to reconstruct and simulate an entire mouse brain, together with individual brain regions and multiple interconnected regions of the human brain. It will further expand its translational goal that builds on Blue Brain's research strengths, with a focus on applications for neurological disorders, neurotechnologies and machine learning. The project's dissemination goal is to deliver open-sourced models and tools to the HBP and the world, and to leverage the HBP platforms to catalyse community collaboration on reconstructing and simulating biologically-detailed models of the brain. These efforts are complementary to other efforts in the Human Brain Project, to which BBP furthermore contributes in designing and building common research platforms and in providing several of the key building blocks of modern brain simulation science.

The ETH Board decided to upgrade two existing research infrastructures and to create a new one. In the context of the update of the Swiss Roadmap for Research Infrastructures, a scientific review of all planned new or substantial upgrades of existing

research infrastructure projects was conducted by the Swiss National Science Foundation (SNSF). The ETH Board evaluated these projects in terms of implementation and funding. Based on the principles of scientific excellence, the ETH Board decided to include the following three research infrastructures in the 2019 Swiss Roadmap and as a strategic priority in the ETH Board's Strategic Planning 2021–2024 for the ETH Domain:

- *HPCN-24 (substantial upgrade of the Swiss National Supercomputing Centre (CSCS) of ETH Zurich)*: In 2009, the Swiss Federal Parliament approved the High-Performance Computing and Networking (HPCN) initiative and charged the ETH Domain and ETH Zurich in particular with its implementation at the Swiss National Supercomputing Center (CSCS; www.cscs.ch) in Lugano. Today, the CSCS User Lab is among the leading research infrastructures of its kind globally. For this to be still true in five to ten years, the supercomputing systems have to be renewed regularly. HPCN-24 is the continuation of the HPCN initiative for the ERI period 2021–2024.

Specifically, in order to build the next generation supercomputing systems that will replace CSCS' current flagship supercomputer "Piz Daint" in the 2020–2021 timeframe, as well as to fund an upgrade of this system in the 2023–2024 timeframe, the User Lab at CSCS will necessitate systematic investments from 2018–2024.

- *SLS 2.0 (substantial upgrade of the Swiss Light Source SLS at PSI)*: The Swiss Light Source (SLS) at the PSI is a third-generation synchrotron light source. With an energy of 2.4 GeV, it provides photon beams of high brightness for research in materials science, biology, chemistry and environmental science. The SLS started operation in 2001. Since then, it has spearheaded much groundbreaking research in biomedicine, engineering and the natural sciences, thanks in large part to the excellent performance of the underpinning electron accelerator and storage ring complex. In addition, it has led the world in industrial exploitation, particularly by the pharmaceutical sector, and spawned numerous new companies, including one of the most successful Swiss technology spinoffs, Dectris. For much of this time, the SLS was a benchmark with regard to how closely its performance matched the theoretical limits defined by its machine parameters. However, with the advent of the next generation of quasi-continuous short-wavelength light sources ("diffraction-limited storage-rings") that yield an emittance and brightness improved by up to two orders of magnitude, it has become imperative to upgrade the SLS in like manner (to "SLS 2.0").

The SLS 2.0 upgrade requires a comprehensive rebuild of the storage ring and magnet lattice, resulting in an improvement in emittance and an associated increase in brightness by a factor of forty compared to the existing performance in the most commonly used hard X-ray regime.

This, combined with advanced instrumentation, will enable much faster imaging of extended objects than is presently feasible and will bridge the so-called "imaging gap" between the macroscopic and the nano world – which is where much of modern science, engineering and medicine reside. In this manner SLS 2.0 will maintain the competitive edge of PSI, the ETH Domain and Switzerland for the next two decades in the most multidisciplinary and sought-after category of large-scale research facilities.

- *Catalysis Hub (a new research infrastructure co-based at ETH Zurich and EPFL)*: Switzerland is one of the world leaders in the transformation of petrochemical-based building blocks into high-value added complex molecules. Irrespective of their target function, these compounds mostly originate from crude oil, a limited natural resource not available in Switzerland. Moreover, their combustion leads to an increase in atmospheric carbon dioxide levels and thereby contributes to global warming. The use of natural resources available in Switzerland – including plentiful carbon in the atmosphere (CO₂) and in unused (inedible) waste biomass, hydrogen in water, and abundant renewable electricity – as well as alternative lower-footprint carbon sources such as methane could allow Switzerland to reduce its use of fossil-based petrochemical feedstocks with the ultimate goal of becoming carbon neutral.

The development of novel catalytic processes and the use of renewable energy sources such as hydro, solar or wind power to drive chemical reactions are key technologies to move from an oil-based economy to a sustainable economy for the production of fuels, feedstocks, fine chemicals and pharmaceuticals. The Catalysis Process Discovery Hub (Catalysis Hub) will be a cornerstone in the successful transition of Switzerland and Swiss industry to a sustainable and innovative economy powered by catalysts of the future. To be successful, the Catalysis Hub will set up an open-access facility for catalysis research beyond the current state-of-the-art that will be devoted to the discovery, characterisation and testing of large numbers of homogeneous and heterogeneous catalysts and catalytic processes. A high-throughput machine-guided approach will allow the rapid discovery and evaluation of leads and parameter space. This requires an integrated workflow, with the fully automated synthesis, characterisation and evaluation of molecular and solid catalysts, and including integrated computational and machine learning (artificial intelligence) approaches.

Core Task 4: Knowledge and technology transfer (KTT)

The institutions' activities in the field of KTT are a crucial element in fostering Switzerland's innovation capacities. Knowledge and know-how are transferred into the economy as well as into public administration by the highly qualified graduates who leave the ETH Domain institutions every year ("KTT through people"). The ETH Domain institutions also foster direct collaboration with the economy and a wide range of KTT activities, including knowledge exchange with public and private actors about public goods, and are actively involved in the continuing design and implementation of the "Switzerland Innovation" park.

Exploiting research findings for the creation of economic value is the fourth Core Task of the ETH Domain institutions. It contributes directly to enhancing Switzerland's innovative capacity. The ETH Domain institutions produce a wealth of know-how, software and technologies in almost all fields of engineering, natural science and life sciences, as well as in the medtech domain. The most important aspect is that the know-how and the technologies generated within the ETH Domain find their way into industrial applications. It is of great importance that the institutions' scientific work should manifest itself in a wealth of products on the market in terms of both numbers and breadth of application.

The ETH Domain institutions' overall KTT philosophy is that KTT is not profit-oriented, but rather aims at making as many technologies as possible available for the Swiss economy and for society at large. Although commercial and financial aspects are considered, maximisation of the socio-economic benefit, contributions to the strength of the economy in Switzerland and worldwide and continuous improvement in the quality of life are far more important objectives. Therefore, the institutions have launched various initiatives to set up a seamless innovation value chain which allows for an efficient and effective KTT. Activities can be broken down into collaboration with industry, knowledge transfer to the public sector and in-house innovation, fostering of entrepreneurship and the foundation of spin-offs, and continuing education (cf. chap. Core Task 1).

KTT through people

Knowledge and know-how are transferred into the economy as well as into public administration by the highly-qualified graduates who leave the ETH Domain institutions every year to take on jobs in the respective areas ("KTT through people"). In addition, representatives of the ETH Domain frequently participate in bodies such as advisory boards, boards of directors, etc. both in the private and in the public sector – an important aspect of know-how transfer. Both of these KTT-through-people routes are important drivers for innovation.

Collaboration with industry and the public sector

The ETH Domain aims to be the main academic partner for Swiss enterprises and public authorities. The six institutions provide access to current research results and in turn benefit from internships for students and from collaboration on the practical com-

ponent of dissertations. Together with their partners from business, they translate their scientific findings into successful marketable solutions and so make a further contribution to KTT. By creating innovative resource-efficient technologies, in particular for Switzerland and developing countries, the institutions of the ETH Domain engage in international KTT and support the humanitarian goals set out in the federal government's foreign policy. The ETH Domain also employs KTT to find solutions to challenges facing public institutions and organisations.

The institutions cultivate efficient KTT with the business and public sector through diverse joint projects, through patents and the issue of licences, through partnerships and spin-offs, as well as via the shared development and use of large-scale research infrastructures, demonstration installations and pilot plants. Expanding their solid basis for strategic cooperation with big companies as well as for collaboration with SMEs allows the institutions to maintain their independence in terms of research and training. They strengthen their partnerships with firms by participating in joint research programmes and infrastructures or in corporate activities at their institutions.

To be able to exploit opportunities to implement research results most effectively and rapidly, the institutions operate topic-specific competence centres either alone or as cooperative ventures within the scope of their autonomy. This form of collaboration is attractive for the institutions of the ETH Domain, companies and other participating higher education institutions.

The ETH Domain institutions have been able to engage in fruitful and trust-based relationships with actors from the private sector. This has enabled them to attract companies to campus and to increase their outreach in terms of KTT. It also serves to attract funding and in-kind contributions from these partners, both with regard to scientific projects (funding of research activities and kick-starting professorships) and for real estate investment. And, most importantly, they can mutually benefit from the exchange between industry and academia. Encouraged by the Confederation's wish for the ETH Domain to diversify its income sources, these third-party funds have become an important source of income for the ETH Domain and a valuable means of enhancing the institutions' capacity to seek further inspiration and to accelerate the implementation of research priorities.

Core Task 4: Knowledge and technology transfer

The ETH Domain institutions promote the transfer of its findings and competencies to society and to the economy in diverse ways. They are continuing to expand their position as a key academic partner to private companies and public administration. They are actively involved in the continuing design and implementation of the Swiss Innovation Park's "Switzerland Innovation" strategy.

Requirements and success factors

- The ETH Domain institutions must maintain diverse forms of technology transfer and entrepreneurship to fit the various needs of the private sector or of public institutions.
- In collaborating with the private and the public sector, the unrestricted autonomy of the institutions for personnel decisions as well as their freedom in the choice of research topics and in their treatment and publication of research findings must be granted by all parties involved.

Challenges

- Translating research results into new and sustainable technologies, into practice and into policies is of growing importance for the competitiveness and innovative capacity of the Swiss economy and the public sector.
- 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.
- Collaboration between the ETH Domain institutions and private companies is encouraged by the Federal Council but is increasingly subject to critical scrutiny.

Measures for 2021–2024

- *Strengthening collaboration with industry and the public sector:* The ETH Domain institutions employ a range of activities and instruments to exploit and commercialise their research findings and to transfer knowledge and technology to both the private and the public sector. These include patenting, licensing, creating spin-offs, consulting and continuous education.
- *Responsible partnering:* In collaborating with the private and the public sector, the unrestricted autonomy of the institutions for personnel decisions as well as their freedom in the choice of research topics, in their treatment and in the publication of research findings must be granted by all parties involved.
- *Fostering of entrepreneurship and creation of spin-offs:* The ETH Domain institutions continue to develop various instruments and programmes to raise the awareness of their students, faculty and employees of the socio-economic value of research results and to stimulate the generation of inventions and business ideas. The institutions foster the entrepreneurial thinking of their students and staff and provide support for successful spin-off creations.
- *"Switzerland Innovation" park:* 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 innovation-friendly conditions.
- *Strategic initiative:* The ETH Domain institutions are actively involved in the ongoing design and implementation of the network of Advanced Manufacturing Technology Transfer Centers (AM-TTC).

Due to their particular role and specific mandates, the institutions of the ETH Domain also contribute significantly to knowledge transfer to the public sector (federal, cantonal and local authorities) or to (professional) associations. This also stimulates innovation, for instance with regard to practical solutions in environmental management or the development of new construction standards. In these cases, innovation often comes directly from the projects in which the ETH Domain institutions are involved and are thus examples of "in-house innovation". Given their specific roles, some of the research institutes contribute mostly in this way to innovation in Switzerland. They are important partners for the Federal Offices (e.g. in the fields of energy, the environment, transportation, public health, etc.), and also for the cantons. The experienced research staff of the ETH Domain's research institutes also act as reliable partners for practitioners and stakeholders, providing independent expert services. The avalanche forecasts by WSL are a typical example: in mountainous regions, it is essential that avalanche hazard information reaches as many people as possible (both public and private actors). Therefore, selling this information on a market is not appropriate. It indirectly supports economic welfare and directly benefits society as a whole.

Fostering of entrepreneurship and the foundation of spin-offs

The ETH Domain institutions have established and continue to develop various instruments and programmes to raise the awareness of their students, faculty and employees of the socio-economic value of research results and to stimulate the generation of inventions and business ideas. Due to the novel nature of technologies resulting from fundamental research, the successful transfer of such technologies to existing industrial players has proven to be particularly challenging. Therefore, spin-offs are an increasingly important vehicle for fostering innovation. Such spin-off companies 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 staff members.

ETH Domain spin-offs have started to have a noticeable impact on the Swiss economy and are an important vehicle for making novel technologies available to society. Widespread spin-off support at the ETH Domain institutions has steadily increased

awareness among students of the economic value of their research and created an entrepreneurial mindset. This represents an important contribution to innovation in Switzerland.

In the context of the ETH Domain's institutions' role in the field of innovation and entrepreneurship, seed or venture funds are of great importance with regard to supporting spin-offs and start-ups in all fields of activities of these institutions. Therefore, ETH Zurich, EPFL and PSI have already created programmes, funds and initiatives aimed at giving such companies access

In the spotlight: Network of Advanced Manufacturing Technology Transfer Centers (AM-TTC)

Advancing digitalisation is having a huge impact on Swiss industry. The international scientific and technical community is developing new manufacturing technologies using the potential of today's very powerful digital technologies. These 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 transfer and the introduction of such new technologies into an industrial application is often challenging and requires competencies and expertise in various fields.

New materials, processes, equipment 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 applied by industrial companies. For these important steps towards a successful technology transfer, specific platforms as well as knowledge of how to operate such platforms are needed. Today such technology transfer platforms often do not exist or are not available to the scientific and technical community in Switzerland.

Establishing a network of Advanced Manufacturing Technology Transfer Centers (AM-TTC) will make it possible to successfully execute the later phases of technology development and translate cutting-edge research results into applicable manufacturing technologies that can be transferred into industrial companies. This will help to turn innovative ideas into real innovations that boost the competitiveness and success of Swiss industry. Currently, Empa, ETH Zurich, EPFL and PSI are preparing the setup (i.e. organisation and governance) of the AM-TTC network in accordance with the Action Plan on Digitalisation. These TTC will be established and managed in close collaboration with other scientific partners as well as with industrial partners. The TTC facilities and services will be available for the whole Swiss scientific and technical community. For the period 2021–2024, the TTC in the network will be financed by the collaborating scientific and industrial partners with financial support under Art. 15 of the Federal Act on the Promotion of Research and Innovation (RIPA).

to venture funds. Empa promotes start-ups and entrepreneurship through the business incubator glatec in Dübendorf and its involvement in Startfeld and the technology and innovation centre Feld3 in St. Gallen. Strengthening such instruments and encouraging their use are thus important facets of entrepreneurship support within the ETH Domain. Moreover, knowledge-sharing among the institutions of the ETH Domain is already intensively practiced and is an important element in fostering capacities and instruments in the field of technology transfer. The ETH Domain institutions have played pioneering roles in promoting technology transfer in Switzerland. Both ETH Zurich and EPFL, for instance, have been co-founders and, together with Empa and PSI, are main drivers behind the swiTT network, whose primary purpose is the exchange of best practices.

The institutions of the ETH Domain are set to continue playing an important role in this regard. For the ETH Domain institutions as such, an important channel for sharing practices and expertise is the informal exchange associated with joint appointments of staff and joint supervision of students at all levels. For instance, this is considered to be an effective channel between individual research institutes of the ETH Domain and specific Departments/Schools at ETH Zurich or EPFL. Furthermore, collaborative research projects provide a channel for informal exchange between the four research institutes. Exchange of best practices is also an important element in terms of benchmarking activities in the field of KTT and fostering entrepreneurship.

Contributions to the “Switzerland Innovation” park

The “Switzerland Innovation” park² is a “project of a generation” aimed at sustainably strengthening and boosting Switzerland as a competitive international location over the long term. It is being 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 local companies and researchers the best possible innovation-friendly conditions, and involve new participants. The innovation park began operations in early 2016, with two hub sites centred on the two Federal Institutes of Technology in Zurich (Park Zurich) and Lausanne (Park Network West EPFL) plus three network locations in Aargau (Park INNOVAARE), Northwest Switzerland (Park Basel Area) and Biel (Park Biel/Bienne). At these locations, the infrastructure will be upgraded and energies will be pooled to create focal centres for industrial research and development.

The ETH Domain institutions' role has from the outset been defined as key for the ongoing establishment of the “Switzerland Innovation” park. The ETH Domain institutions have always contributed in a productive manner to this project, having respected the distribution of responsibilities among the political authorities involved: ETH Zurich and Empa are participants at Park Zurich located on the Dübendorf airfield site, EPFL has a leading role in Park Network West EPFL – a network of six parks in Western Switzerland covering all innovation areas – and PSI plays a central role in Park INNOVAARE at Villigen in the Canton of Aargau.

² www.switzerland-innovation.com/

Further activities: National tasks, contributions to the Swiss higher education system and dialogue with society

In parallel with its Core Tasks, the ETH Domain also performs numerous national tasks. In its efforts to contribute to implementing the Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA), the ETH Domain is actively engaged in shaping Switzerland's higher education sector, while protecting institutional autonomy. Last but not least, the institutions of the ETH Domain investigate societally relevant topics and are committed to raising public awareness of research and technological developments.

National tasks

The ETH Domain performs numerous national tasks (cf. Figure 4) in the interests of society and on behalf of the Swiss Confederation: Often the sole expert in Switzerland at the university level, the ETH Domain meets its responsibility by providing scientific services and research infrastructures with a nationwide reach. These important services for Switzerland often derive their high quality from their close proximity to research. In turn, they show the students specific areas in which their fields of activity are applied, thus conveying a valuable perspective.

Abb. 4: Examples of national tasks of the ETH Domain

Lead institution(s)	National task
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)

Many of these national tasks are either based on requirements set by legislation, or have been integrated into the ETH Domain in the past and contribute to the fulfilment of international obligations. These national tasks tie up a substantial share of the federal funding received. Since the respective objects and their long-term preservation (e.g. collections of Swiss cultural assets) fall under the public sector, these tasks do not normally generate revenue, but they create considerable added value. Given that Switzerland's only national experts at the university level are sometimes to be found within the ETH Domain, the latter is aware of the particular responsibility it bears. It aims to continue delivering high-quality, science-based services for the good of the country.

Contributions to Swiss higher education system

All ETH Domain institutions hold the deeply rooted conviction that only teaching and research which is competitive with other world-leading institutions can yield sustainable benefit for the country (e.g. in terms of highly qualified graduates trained for private and public actors in Switzerland, technological applications at the service of society, jobs created in R&D, etc.). Accordingly, the ETH Board is convinced that their world-class positioning and the dynamic to which this contributes within the Swiss academic community represent their core contribution to the Swiss higher education system. The benefit this generates can be illustrated by the following aspects:

- Given that science and technology are clearly among the most important resources on which Switzerland's welfare depends, the fact that both ETH Zurich and EPFL rank among the top universities worldwide and are even leaders in continental Europe is a vital element in strengthening Switzerland as a scientific location. Moreover, all institutions of the ETH Domain rank well above the world average in terms of bibliometric data.
- Students – undergraduates and graduates as well as those in continuing education – have the opportunity to learn from the best researchers worldwide from the very beginning and are exposed to stimulating competition in terms of ideas and performance that trains them for their careers in private industry, in academia or the public sector.

- Researchers, both from higher education and research institutes and from the private sector, have access to knowledge and world-class infrastructure benefiting their own work; this is evident, for instance, from the fact that during the past years several large and multinational companies have set up or entirely moved their R&D divisions as close as possible to one of the ETH Domain's institutions.

Switzerland's dual education system, with vocational and academic tracks, is designed to cater for students according to their specific talents and interests. The complementarity of these two tracks produces a balanced pool of highly trained, sought-after professionals at various levels and with different skills profiles. This promotes the sustainable development of the Swiss economy and represents a competitive advantage for Switzerland. As part of Swiss-wide higher education policy coordination, the ETH Board works towards consolidating the very strong position of ETH Zurich and EPFL in the international competitive arena. It is committed to ensuring the continued and complementary division of tasks between universities of applied sciences and cantonal universities, and ensuring that the different groups of students have access to more clearly defined educational and research profiles. Therefore, the profiles of ETH Zurich and EPFL should remain distinct from those of the Universities of Applied Sciences, which have the mandate to educate students exclusively in a practice-oriented manner in close collaboration with industry. Ideally, outstanding students from the Universities of Applied Sciences are able to enter study programmes at ETH Zurich or EPFL, expanding options for students within the Swiss dual education system while upholding the quality-based transfer criteria. This preserves, and therefore strengthens, the distinct profiles of each of the higher education institutions in Switzerland.

The ETH Domain cultivates academic cooperation with other Swiss higher education institutions and builds on this to benefit from complementary expertise and curricula. Cooperative projects at the individual and institutional level have in the past proven to be sustainable and efficient when they came about at the initiative of the actors involved. The ETH Board thus attaches importance to the autonomy of the institutions, allowing them to enter into or terminate institutional collaborative ventures as required.

In its efforts to implement the Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA), the ETH Domain is actively engaged in shaping Switzerland's higher education sector. The ETH Domain's large and costly research infrastructures, which are of Swiss-wide significance, are one crucial contributory factor and its contributions to the medical education are another. Furthermore, the ETH Domain contributes to the operationalisation of recent developments in the scientific community in Switzerland and beyond – such as the principle of open data in science.

Further activities: National tasks, contributions to the Swiss higher education system and dialogue with society

Measures for 2021–2024

- *National tasks:* The ETH Domain meets its responsibility by providing high-quality scientific services and research infrastructures with a nationwide reach.
- *Cooperation and coordination within the Swiss higher education system:* The ETH Domain is actively engaged in shaping Switzerland's higher education sector, while protecting institutional autonomy. In particular, the ETH Domain supports the efforts led by swissuniversities to gain a systematic overview of "open research data". For its field of research, the ETH Domain is ready to play a leading role and to define conditions and elaborate suitable measures to make suitable research data available.
- *Dialogue with society:* The institutions of the ETH Domain investigate socially relevant topics and are committed to raising public awareness of research and technological developments. They maintain a dialogue with society in general and specifically with high schools.

Dialogue with society

Diverse technologies and research applications feature prominently in everyday life today. The institutions of the ETH Domain investigate socially relevant topics and are committed to raising public awareness of research and technological developments. They advise government authorities, encourage public dialogue and provide well-founded scientific contributions to support the best political framework conditions for a future-oriented society (evidence-based policy-making). In addition, they create national and international platforms for the scientific scrutiny of current issues (e.g. urban planning, healthcare policy and climate research). They coordinate with other actors in the field of education and research and strengthen dialogue and fact-based communication with society. This is their reaction to the changes in the media landscape and the emergence of social media. By doing so, the institutions of the ETH Domain play a key role for the benefit of society as well as making concrete contributions to sustainable development.

Maintaining a dialogue with baccalaureate schools and teacher training providers, ETH Zurich and EPFL are committed to ensuring the quality and appeal of baccalaureate school mathematics and natural sciences curricula. They visit and invite school classes, support students working on ambitious high school diploma projects and organise events to inform final year baccalaureate school students about their diverse course offering and specific entrance requirements. Furthermore, the institutions of the ETH Domain have created special programmes designed to arouse students' interest in the MINT subjects, including the MINT Learning Center at ETH Zurich, the EPFL programme "Les Sciences, ça m'intéresse" and the iLab student laboratory at PSI, as well as various initiatives. In particular, they promote the programming skills of children and young people.

III. Science policy – a key success factor

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Core prerequisites for international competitiveness

Switzerland's internationality and openness are prerequisites enabling the ETH Domain to generate social and economic benefit for our country. So that ETH Domain institutions can operate flexibly and sustainably in this highly dynamic global environment, the institutions depend, in turn, on a high degree of autonomy. Such autonomy is fundamental to the definition and implementation of new strategic developments which will be relevant tomorrow for the ETH Domain and for Switzerland as an academic and economic focal point in Europe. Such dynamic and independent action on the part of the institutions hinges on basic funding from the Confederation that is stable, reliable and can be used with the greatest possible flexibility.

As stipulated in the Federal Council's Strategic Objectives 2017–2020 for the ETH Domain, the Domain's institutions aspire to highest quality in all their areas of research, in teaching, 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 for the ETH Domain institutions and the Swiss higher education and research system 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.

Internationality and openness

Switzerland's internationality and openness as a centre of education and research 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.

Teaching: The international reputation of Switzerland as a 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 at bachelors or master's and then doctoral level ensures a stepwise exposure to the international environment.

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. 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.

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, benefiting Swiss researchers at infrastructures abroad as well.

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.

Autonomy

Autonomy is one of the core prerequisites for the successful positioning of the ETH Domain and its institutions for future challenges. 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 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) upon the ETH Domain institutions and on the 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.

a) 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 Domain by the Federal Council. Strategic decisions that are of relevance for the ETH Domain as well as the ensuing allocation of the Domain's global budget to the individual institutions, to strategic projects and to 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 of the ETH Domain's autonomy concerns the implementation of the Higher Education Act (HEdA)³. In this regard, the ETH Board must make sure that the autonomy of the Domain is not restricted by the overarching coordination processes set out in the HEdA, even though the ETH Domain remains under the auspices of the ETH Act (in relation to aspects such as governance, financial commitments and decision-making processes).

b) Academic and financial autonomy of the institutions

The autonomy granted to the institutions of the ETH Domain gives them the 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 co-operation with the private sector.

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. 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 doubts remain with regard to the ETH Domain's yearly budgets, as these are not exempt from the budget cuts which the Confederation may decide on as a part of its austerity programme.

As the basic tasks of the ETH Domain institutions bind most of the resources, budget cuts force the institutions to cancel or postpone investments in research infrastructure or selected research topics, as a precautionary measure. Moreover, spending cuts 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 (gebundene Ausgaben). 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 protection 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 the coming 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 the SNSF and the EU plus 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 the amounts actually received. Therefore, stable funding by the Confederation still provides a crucial and indispensable foundation.

³ Federal Act on Funding and Coordination of the Swiss Higher Education Sector, of September 2011 (status as at 1 January 2018)

Specific requirements for 2021–2024

The full association of Switzerland with the 9th EU Framework Programme for Research and Innovation – Horizon Europe 2021–2027 – is a key success factor for Switzerland's innovative capacity and for the Swiss science community.

International collaboration is crucial for the quality of science and research at the ETH Domain institutions, because cutting-edge research today is often the result of several research groups working together, often from different countries. Working with scientists outside Switzerland provides access to valuable additional expertise. It also opens up new ways of sharing costs, and makes it possible to tap into alternative funding sources. International collaboration in research projects is of growing importance, and scientific publications from international collaboration achieve greater impact. 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, to obtain access to major research infrastructures worldwide and to participate in international networks.

The next European Framework programme for Research and Innovation, "Horizon Europe", is due to start in 2021 and will run for seven years. Like the ongoing "Horizon 2020" programme, the upcoming programme will promote European integration and collaboration on global challenges such as health or climate change. But it will also focus on innovation, which will be of great interest to Swiss SMEs in particular. The selection process in itself is beneficial for researchers in Switzerland: they compete for grants with the best researchers in the same field from all over Europe. This drives quality standards up. Another key aspect is mobility within Europe, which will be promoted under specific Horizon Europe schemes.

Science in Switzerland is dependent on the country's strong reputation as a reliable partner and on stable international relations, particularly with the EU. When collaborating internationally becomes difficult, research quality suffers. Therefore, it is vital that scientists working in Swiss research institutions have unhampered access to international networks and international competitive research funding, notably to the 9th European Framework Programme for Research and Innovation as well as the Euratom research and training programme. This would also benefit Europe – because of Switzerland's strength in research and the substantial financial contribution it can make. If Europe is to compete with North America and Asia in the scientific and business spheres, all the continent's countries must work together.

For Switzerland to have only a partial association with, or even be excluded from, the 9th Framework Programme or Euratom would discriminate against Swiss-based researchers and thus impair Switzerland's scientific excellence. Such a scenario would harm our country because research and innovation are the drivers of economic and social prosperity and change: national funding schemes are no replacement for European cooperation and competition.

IV. Financial requirements 2021-2024

IV. Financial requirements 2021–2024

In order to implement its strategy with the related measures, the ETH Board is asking the Federal Council and Parliament to approve a budget appropriation of CHF 11,053 million for the ETH Domain for the period 2021–2024. On the basis of the current financial planning for the year 2020, this amount would represent a mean annual growth rate of 3.1 % (including compensation for an assumed annual inflation rate of 1 %).

I. Financial requirements of the institutions

The ETH Board allocates the lion's share (approximately 95 %) of the annual federal funding to the six institutions to enable them to fulfil their basic mandate. The basic mandate of the ETH Domain institutions entails teaching, research (including research infrastructures), and knowledge and technology transfer, plus their role in society and in Switzerland as a whole.

Innovative, research-based education: The growing number of students, doctoral students and professors, coupled with the diversification of curricula and of the learning environment, have created a need for more investment in teaching, training and learning infrastructure at the six institutions. Specific efforts to maintain the quality of the research-based education are also called for.

Research: 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, the ETH Domain institutions need to increase the number of professors and research groups in the period 2021–2024. Up to 80 additional professorships and research groups will make it possible to guarantee strong links between training and state-of-the-art research, to create new opportunities in research and teaching, to strengthen already established areas of research and to advance into new ones. In addition, this capacity-building and expansion of competencies will foster the ETH Domains' capacity for anticipating and responding to the country's challenges, as well as for providing the scientific and technical basis to support the initiatives of the respective authorities, e.g. in energy research or digitalisation-related activities.

Operation of existing research infrastructures: The ETH Domain has long-standing expertise and a leading position in planning, implementing and operating large-scale research infrastructures. The institutions rely on continuous reinvestment to keep the existing large-scale facilities competitive at the international level and to allow scientific agenda-setting in strategically important areas by acquiring or designing new large-scale research infrastructures. The current and planned large-scale research infrastructures, with specific user and service labs of national importance based in the ETH Domain, need to be financed, operated and developed in such a way that academia and industry have access to these state-of-the-art research infrastructures.

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 for the benefit of the country.

Real estate management: The ETH Domain coordinates property and real estate management and is responsible for maintaining their value and function. The ETH Domain plans and develops its real estate portfolio in the medium and long term so as to take account of research and teaching needs as well as the requirements of the Swiss Confederation as the owner of the real estate.

Working conditions: Attractive, internationally competitive working conditions are designed and implemented to motivate employees, help them to maximise their performance and support their professional development. The PUBLICA pension scheme needs to be continually developed to ensure certainty and security in keeping with demographic and socio-economic trends.

Compensation of inflation: The indicated financial need for the institutional base budgets includes compensation for assumed annual inflation of 1 %.

II. Financial requirement for strategic initiatives

1. Strategic Focus Areas

Strategic Focus Areas (SFAs) address key societal challenges and boost essential 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. The three SFAs "Personalized Health and Related Technologies (PHRT)", "Data Science" and "Advanced Manufacturing" initiated in the period 2017–2020 will be continued during the period 2021–2024 in order to realise their full potential. The ETH Board plans to allocate a total of CHF 115m to these three SFAs.

2. Large-scale research infrastructure

State-of-the-art infrastructure is of utmost importance to the innovative, solution-related advancement of cutting-edge research that is crucial to ensuring Switzerland's international competitiveness as a centre of research and innovation. In the period 2021–2024, the ETH Domain is planning to realise the following projects of strategic priority: continuation of the "Blue Brain Project" (EPFL), upgrades to IT infrastructure (HPCN-24) at the CSCS and at the Swiss Light Source (SLS 2.0), and realisation of the Catalysis Hub as a contribution to catalysis-driven, sustainable chemical processes (incl. provision of fuels and feedstock for a green economy). The requested funding for these four projects amounts to CHF 304m.

III. Financial requirement for the implementation of federal strategies and decisions

1. Accelerator facilities at PSI

Provisions for the decommissioning and disposal of the accelerator facilities at PSI amount to CHF 44m for the period 2021–2024.

2. Implementation of the Action Plan on Digitalisation

The federal Action Plan on Digitalisation is designed to support society in coping with the opportunities, risks and challenges arising in this area. The Action Plan entails two measures to be implemented by the ETH Domain, namely capacity-building and the expansion of competencies in ICT/computer science at ETH Zurich and EPFL, and setting up a national network of Advanced Manufacturing Technology Transfer Centers (AM-TTC). For the period 2021–2024, the resulting costs of the seven additional professorships established in 2019 and 2020 total CHF 42m (i.e. CHF 1.5m per year per research group). For the period 2021–2024, the TTC in the network will be financed by the collaborating scientific and industrial partners with financial support under Art. 15 of the Federal Act on the Promotion of Research and Innovation (RIPA).

IV. Financial requirements 2021–2024

Figure 5: Financial requirements of the ETH Domain for the period 2021–2024

In million CHF	Financial requirements 2021–2024
I. Financial requirements of the institutions (base budgets) for fulfilling their basic mandate	10,548
These include (non-exhaustive list):	
<ul style="list-style-type: none"> - strategic development of the institutions in educational (innovative, research-based education), research and KTT activities - measures to tackle the increasing numbers of students and doctoral students and uphold high standards of teaching and supervision - creation of up to 80 additional professorships and research groups - continuing activities within the scope of the Action Plan on "Coordinated Energy Research Switzerland" and digitalisation-related activities (e.g. capacity-building and expansion of competencies) - operation of existing research infrastructures with specific user and service labs - performance of national tasks - further development and management of real estate - maintaining attractive and internationally competitive working conditions - compensation for assumed annual inflation of 1 % 	
II. Financial requirement for strategic initiatives	419
1. Strategic Focus Areas (SFA)	115
SFA Personalized Health and Related Technologies (PHRT)	50
SFA Data Science	40
SFA Advanced Manufacturing	25
2. Large-scale research infrastructures	304
Blue Brain Project	88
HPCN-24	92
SLS 2.0	99
Catalysis Hub	25
III. Financial requirement for the implementation of federal strategies and decisions	86
Provisions for the decommissioning and disposal of the accelerator facilities at PSI	44
Implementation of specific measures under the Action Plan on Digitalisation	
a) Capacity-building and expansion of competencies in digitalisation (costs arising from additional professorships in the area of computer science)	42
b) Network of Advanced Manufacturing Technology Transfer Centers (AM-TTC)	— ⁴
Total	11,053
<i>Corresponding annual growth rate of federal funds⁵</i>	<i>3,1 %</i>

⁴ For the period 2021–2024, the TTC in the network will be financed by the collaborating scientific and industrial partners with financial support under Art. 15 of the Federal Act on the Promotion of Research and Innovation (RIPA).

⁵ Basis: planned financial contribution of the Federal Council to the ETH Domain for 2020 (*finance plan as at December 2018, i.e. CHF 2,558,729,900*).

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