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Federal Department of Economic Affairs, Education and Research
EAER

State Secretariat for Education, Research and Innovation SERI
Research and Innovation

Swiss Roadmap for Research Infrastructures in view of the 2021–2024 ERI Dispatch

(Roadmap for Research Infrastructures 2019)

Document acknowledged by the Federal Council on 17 April 2019 as an outline paper for the 2021–2024 ERI Dispatch

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Management summary

The 2019 Swiss Roadmap for Research Infrastructures is a strategic planning instrument. It provides an overview of newly planned national infrastructures and of Switzerland's participation in international research infrastructures. It also reviews the progress made in realising the infrastructures proposed in the 2015 Roadmap. It is one of the documents forming the basis for drawing up the 2021–2024 ERI Dispatch and the dispatch on funding for the EU framework programmes (EU Dispatch) in the coming years. Moreover, this Roadmap gives an outline of medium-term funding requirements at national and international level. It does not contain details of any funding decisions or decisions on the allocation of federal funds.

Research and innovation are key to economic and social progress. Researchers in all disciplines rely on having excellent research infrastructures (RIs) in order to carry out their activities. These include large-scale research facilities (e.g. particle accelerators), e-infrastructures (e.g. high-performance computers) and databases. All areas of research are affected, from physics to biology, through computer science and the humanities to social sciences. The majority of RIs are used for activities in several fields simultaneously. As the multidisciplinary nature of research projects increases and technology develops apace, the importance of such expensive RIs which can be used across research fields is increasing, as is the need for new infrastructures. This situation requires funding bodies to conduct medium- and long-term financial planning in which they carefully compare the benefits of establishing new national research infrastructures with those of participating in international ones, and weigh up the option of building new RIs against that of discontinuing, maintaining or developing existing infrastructures.

The 2019 Swiss Roadmap for Research Infrastructures provides a general overview of new RIs planned with a view to the 2021–2024 ERI Dispatch and an update on those introduced in the 2015 Roadmap (compiled for the 2017–2020 ERI Dispatch) which also require funding going forward. A more comprehensive inventory including many infrastructures in use before the 2017–2020 period can be found in the 2015 Roadmap for Research Infrastructures published by the State Secretariat for Education, Research and Innovation (SERI).

SERI coordinated the process for drawing up the Roadmap in conformity with the Federal Act on the Promotion of Research and Innovation (RIPA). The proposals for research infrastructures in Switzerland put forward by researchers were selected by the responsible bodies (ETH Board and swissuniversities) according to inclusion criteria and other criteria specific to the institution (e.g. internal strategies). This preselection phase (Phase 1) was followed by two more stages in the evaluation process. In Phase 2, the Swiss National Science Foundation (SNSF) examined the proposals submitted on the basis of scientific criteria, categorising them into three groups: A, B and C. In a third evaluation phase (Phase 3), the proposals were considered by the ETH Board and swissuniversities on the basis of planning, governance and management criteria, and in terms of their financial viability and the institutional support they might attract. In total, the ETH Board and swissuniversities selected 15 of the proposed RIs for implementation in Switzerland, eight of which are completely new and seven of which involve substantial upgrades of existing RIs. Of the 15 projects evaluated by the SNSF, seven (of which four are upgrades) were assessed as being of high scientific importance (Priority A). Only those proposals which successfully passed the Phase 3 review are included in this Roadmap.

As part of the process of compiling the Roadmap, the SNSF was also asked by SERI to examine the importance of Swiss participation in 15 international infrastructures and organisations and to provide its opinion on their importance. The SNSF identified twelve of these as priority infrastructures ('high importance').

1. Introduction

1.1. Content of the roadmap report

The State Secretariat for Education, Research and Innovation (SERI) was responsible for drawing up this 2019 Roadmap for Research Infrastructures ('2019 Roadmap') and for the process conducted with its partners: the ETH Board, the Swiss Conference of Rectors of Higher Education Institutions (swissuniversities) and the Swiss National Science Foundation (SNSF).

Section 2 provides a retrospective look at the current ERI period and the national and international obligations resulting from the 2015 Roadmap. An update on these national projects (implementation status) can be found in Annex A2. Section 3 presents the process of drawing up the 2019 Roadmap. Section 4 contains the results of the survey procedure (Phase 1) and the SNSF's evaluation, and an overview of the research infrastructures recommended by the SNSF (Phase 2).

Section 5 looks in greater detail at the RIs recommended by the SNSF, how they were assessed by the responsible bodies, and the final findings (Phase 3). Section 6 describes the other measures to promote RIs by the funding bodies (SNSF, Swiss Academies of Sciences). Finally, section 7 presents the projects planned in the European ESFRI[1] Roadmap and by international research organisations.

Annex A1 lists the recently announced national research infrastructures of high scientific importance and Annex B1 lists the international research infrastructures which Switzerland will consider participating in. Finally, Annex B2 lists the international research organisations in which Switzerland participates or intends to participate.

1.2. Aim of the roadmap

In many disciplines research infrastructures are an essential prerequisite for obtaining new scientific results, developing specialised fields or exploring new fields of research. The need for such research infrastructures has increased in recent years and has thus led to a rise in funding needs. Medium- to long-term coordination is also required for major research infrastructures of national or international importance, as is careful planning to ensure that limited resources are allocated as efficiently and effectively as possible and that research and innovation players are able to access them as appropriate and required.

Where Switzerland participates in an international research organisation based on an international agreement, legal and foreign policy aspects further increase the need for planning and coordination.

Against this background, this 2019 Swiss Roadmap for Research Infrastructures (2019 Roadmap) serves as a planning instrument and is one of the basis documents used by the Confederation to make budgetary decisions regarding the 2021–2024 ERI Dispatch and EU Dispatch. The Roadmap is neither a report to attract special funding nor a procedure involving funding decisions.

[1] European Strategy Forum on Research Infrastructures (ESFRI).

The funding decisions under the 2021–2024 ERI Dispatch regarding the realisation of the various research infrastructure projects in which funding is provided by the Confederation[2] are taken on the following bases:

- higher education institutions' strategic planning and the multi-year programmes of the relevant supporting bodies;
- results of the evaluation procedure of this Roadmap;
- analysis of the effective need for specific federal support within the meaning of the Subsidies Act (SR 616.1);
- budgetary framework for multi-year financial decrees (ERI and EU) as determined by the Federal Council for the 2021–2024 period.

[2] See section 5.1 for an explanation of the Confederation's responsibilities.

2. Review of the ERI period 2017–2020

2.1. Introduction

The 2019 Roadmap is the third to be published by SERI. The two previous reports were published in 2011 and 2015. The first Roadmap served as a basis for the section on research infrastructures in the 2013–2016 ERI Dispatch. It constituted above all a response to the 2008 European roadmap ESFRI, which invited European countries to establish national roadmaps in order to improve planning and funding conditions for large-scale research infrastructure projects coordinated at international level.

2.2. 2017–2020 ERI period: 2015 Swiss Roadmap for Research Infrastructures and its implementation

The 2015 Swiss Roadmap for Research Infrastructures (2015 Roadmap) addressed, on the one hand, infrastructures with a national mission and on the other, international structures and Switzerland's possible participation in them.

On 24 June 2015 the Federal Council acknowledged the final report on the 2015 Roadmap. After considering the effective need for specific federal support and reviewing the availability of financial resources, in its 2017–2020 ERI Dispatch to Parliament the Federal Council proposed continuing to fund the following existing research infrastructures:

a) National research infrastructures

The Federal Council expects the ETH Domain to run large-scale RIs of national and international importance, to continue to develop them and to make them available to researchers. Under the 2015 Roadmap and in accordance with its 2017–2020 strategic planning, in the 2017–2020 period the ETH Board supports:

- infrastructures which form part of the 2015 Roadmap process:
  - HPCN/HPCN-20 (ETHZ);
  - Construction of the new ATHOS line of the SwissFEL x-ray free electron laser at the PSI;
  - Swiss Light Source SLS 2.0 (PSI);
  - Initiative for Data Science in Switzerland (Swiss Data Science Center) (ETHZ, EPFL);
  - Swiss Plasma Center (EPFL);
  - Next Evolution in Sustainable Building Technologies (NEST) (Empa, Eawag);

- other research infrastructures outside of the 2015 Roadmap process:
  - Optimisation of the CMS detector at CERN (led by the ETHZ);
  - Blue Brain Project at the EPFL (part of the European flagship Human Brain Project).

Under the 2017–2020 ERI Dispatch, continued development of existing infrastructures and the creation of the new infrastructures mentioned above will cost around CHF 531 million in the ETH Domain (of which about CHF 452 million will be assumed by the Confederation).

The infrastructures of the **cantonal universities** are funded primarily by the institutions themselves and to a lesser extent by the Confederation via funding awarded under the Higher Education Act (HEdA). The research infrastructures planned by the universities in the 2017–2020 period and which feature in the 2015 Roadmap are described in Annex A2.

In accordance with **Article 15 RIPA** (contributions to research facilities of national importance), **SERI**, as the competent body, allocated funding for the following projects planned in the Roadmap:

- Clinical research services platform Swiss Clinical Trial Organisation (SCTO; includes the Swiss Research Network of Clinical Pediatric Hubs SwissPedNet and the European network EPCTRI[3]);
- New technology competence centres:
    - Balgrist Campus Zurich (orthopaedics platforms) and
    - sitem insel Bern (translational medicine infrastructure).

The cost to SERI for these three infrastructures is about CHF 55 million for the 2017–2020 period.

Other federal funding measures for research infrastructures (2017–2020 period).
The research funding institutions have set out in greater detail the proposals they outlined in the 2015 Roadmap.

In a review of its portfolio, the **Swiss National Science Foundation (SNSF)** set out its principles for funding research infrastructures in the 2017–2020 period and decided to allocate funding to new RIs in the form of start capital, generally for a maximum period of ten years, provided a sponsoring body provides follow-up funding. Since this principle cannot be fully applied during the 2017–2020 funding period, additional evaluations have been necessary.[4]

During the current funding period, the SNSF continues to support various RIs with international involvement in a number of fields: environment, climate research, medicine, and humanities and social sciences.[5] The SNSF helps higher education institutions to meet programme investment costs via the R'Equip programme (funding research equipment) and the Funding LArge international REsearch projects programme (FLARE[6]).

The SNSF provides about CHF 232 million in funding for research infrastructures (including FLARE) from resources made available in the 2017–2020 ERI Dispatch.

The **Swiss Academies of Arts and Sciences** fund long-term undertakings (SAHS)[7] and the science secretariats (SCNAT) to the amount of CHF 43.6 million under the 2017–2020 ERI Dispatch. In the current ERI funding period, the SAHS has also assumed funding responsibility for eight editions, formerly with the SNSF, whereby funding of CHF 10.6 million remains registered with the latter.

In the current funding period, the Confederation (SERI) also has launched a **national promotion initiative** on **personalised medicine**, and commissioned the Swiss Academy of Medical Sciences (SAMS) to establish a national data infrastructure in the clinical field. This initiative (SPHN) [8] was set up in conjunction with higher education institutions and university hospitals, with the SNSF as a funding body, and is coordinated with the ETH Domain's initiative on personalised medicine (PHRT[9]: strategic focus of the ETH Board).

For these two initiatives, funding of CHF 70 million is available for SERI and CHF 50 million for the ETH Domain.

b) International research organisations and infrastructures

Switzerland's participation in international research organisations conforms to the objectives set by the Federal Council in Switzerland's International Strategy on Education, Research and Innovation (on 4 July 2018). A key message in this strategy is that "infrastructures, programmes and services abroad are open to Swiss actors and serve to safeguard and improve the quality of their own services".

[3] The EPCTRI (European Paediatric Clinical Trial Research Infrastructure) was integrated into the European Clinical Research Infrastructure Network (ECRIN).

[4] One of the effects of rationalising the portfolio was the transfer of long-term undertakings from the SNSF to the Swiss Academy of Humanities and Social Sciences (SAHS).

[5] See section 7.

[6] The FLARE programme (Funding LArge international REsearch projects) aims to facilitate the development, construction, maintenance and operation of research infrastructures for major international experiments in particle physics, ground based astrophysics and astroparticle physics.

[7] The SAHS is providing CHF 2 million in funding to DaSCH in the 2017–2020 funding period.

[8] Swiss Personalized Health Network.

[9] Personalized Health and Related Technologies.

With regard to investments in international research organisations, it should be noted that Switzerland's commitments in this context are binding under international law. New projects carried out within the framework of international research organisations of which Switzerland is already a member are therefore given funding priority. Of secondary importance is the continued participation in international research organisations in which Switzerland is associated for a set period of time. Finally, joining other existing or new international research organisations is Switzerland's third priority.

Under the 2017–2020 ERI Dispatch and on the basis of the 2015 Roadmap, Parliament approved the budget for renewing Switzerland's temporary participation in the Institut Laue-Langevin (ILL) and for its participation in the creation of the Cherenkov Telescope Array (CTA) organisation.[10] However, no budget was allocated for investment in the new international projects proposed in the 2015 Roadmap, SKA, ELI and LBNF-DUNE, for financial reasons or because of their low level of maturity. However, the projects have been further developed and have matured over the past three years, and so their importance for Switzerland in the 2021–2024 period can now be assessed.[11]

ESFRI projects and the ERIC legal form

As autonomous institutions, higher education institutions (and research institutes) can participate in projects conducted by the European Strategy Forum on Research Infrastructures (ESFRI). The Confederation only has direct competence when participation is part of an international agreement, for example when an ESFRI project adopts the specific legal form in EU law of a European Research Infrastructure Consortium (ERIC). ERICs are becoming increasingly common.

The international research infrastructures organised in the form of an ERIC benefit from a stable and lasting legal and organisational framework within which to conduct their activities. They enjoy the same privileges as intergovernmental organisations in those countries that recognise this legal form. Furthermore, these international RIs have greater ease of access to EU funding. From the point of view of federal research promotion, therefore, achieving the best possible access for Swiss research institutions and groups of researchers to all ERICs of strategic interest is a high priority. To do this, however, Switzerland would under normal circumstances have to be a member of the ERIC.

However, to become a member of an ERIC, a country has to have declared to the European Commission that it recognises the EU decree establishing this specific legal form for the given consortium. Under current Swiss legislation, this recognition has to be approved by Parliament on a case-by-case basis.

[10] See section 7.2

[11] See section 7.2

ESFRI projects in which Switzerland is involved during the 2017–2020 period (in principle with non-binding observer status in terms of international law) and which have become ERICs (as at 31.12.2018) are the following:

Biomedical research/clinical research:

- **BBMRI ERIC**: Networking of bio-databases; CH node: Swiss Biobanking Platform (funding under SNSF budget).
- **ECRIN ERIC**: Networking of clinical study centres; CH node: Swiss Clinical Trial Organisation (SCTO, funding under SNSF budget).
- **ELIXIR**: Bio-informatics structures in the EMBL[12]; CH node: Swiss Institute for Bioinformatics (SIB, federal funding under Art. 15 and Art. 28 RIPA/commitment appropriation for international cooperation in research; no ERIC structure; Switzerland entered into an international agreement during the 2013−2016 ERI period).

Materials and life sciences research:

- **European Spallation Source ERIC (ESS ERIC):** Neutron source for research into materials and life sciences in Lund (Sweden), which will be the most powerful instrument of its kind in the world; Switzerland entered into an international agreement during the 2013−2016 ERI period.

Environment/climate research:

- **ICOS ERIC:** Atmospheric physics and ecosystem research; CH node: ETHZ and HFSJG[13] (funding under the SNSF budget and own funding from ETH Domain institutions).
- **EPOS ERIC:** Seismic research; CH node: ETHZ/SED[14] (ETH Domain and others).
- **ECCSEL ERIC:** Various research infrastructures dedicated to research into the capture, storage and use of carbon dioxide for energy production (ETH Domain and others).[15]

Humanities and social sciences research:

- **ESSurvey ERIC:** Long-term social science survey; CH node: FORS[16] (funding under Art. 15 RIPA).
- **CESSDA ERIC:** Brings together social science data archives; CH node: FORS (funding under Art. 15 RIPA).
- **SHARE ERIC:** Long-term social science survey; CH node: IEMS[17] and FORS (funding under Art. 15 RIPA).
- **DARIAH ERIC:** European network of digital research infrastructures for the arts and humanities (universities are members as consortium partners; no formal representation at ministerial level).[18]

[12] European Molecular Biology Laboratory.

[13] High Altitude Research Stations Jungfraujoch & Gornergrat.

[14] Swiss Seismological Service (SED, Schweizerische Erdbebendienst).

[15] Observer status for ECCSEL ERIC due to be renewed in 2020.

[16] Swiss Centre of Expertise in the Social Sciences (FORS).

[17] Interfaculty Platform in Health Economics and Management (IEMS), University of Lausanne.

[18] Switzerland is no longer officially represented. Seven Swiss universities and the SAHS currently participate in DARIAH as consortium partners.

3. 2019 Swiss Roadmap for Research Infrastructures

3.1. Aim and purpose in accordance with RIPA

This Roadmap provides an overview of newly planned research infrastructures (see Annex A1) and the state of progress of infrastructure projects planned in the 2015 Roadmap (Annex A2). It is thus an instrument to ensure coherence between research funding measures at national and international level in accordance with the legal mandate (Art. 41 RIPA and Art. 55 RIPO).
The Roadmap refers to the European definition of a research infrastructure, i.e. on the following definition:

- The research infrastructure makes a major contribution to the development of a field of research (academic added value);
- The research infrastructure is used intensively by Swiss researchers (of national importance);
- Access to the research infrastructure is regulated for communities of national and international researchers;
- The research infrastructure may be situated in a single location or may be part of a network comprising several sites and a central management structure;
- The research infrastructure does not primarily pursue autonomous research but is available to researchers for their various projects.

Moreover, the infrastructure must meet the following criteria[19] (new compared to the 2015 Roadmap):

- The research infrastructure is new or a significantly upgraded existing infrastructure;
- The level of maturity is advanced; implementation is imminent;
- The research infrastructure has investment and operating costs of at least CHF 5 million for the 2021–2024 period.

Typically, Swiss research infrastructures are developed and run on a medium- to long-term basis (generally more than ten years). They therefore extend beyond the planning period of an ERI dispatch.

3.2. Responsibilities and procedure

3.2.1. Responsibilities

Under RIPA, funding for research infrastructures is above all the responsibility of the higher education institutions and research institutes in the ETH Domain. The SNSF assumes a secondary role, supporting research infrastructures which aid the development of specialist fields in Switzerland. The Confederation, meanwhile, is responsible for subsidiary support for research infrastructures of national importance and for Switzerland's participation in research infrastructures coordinated at international level (see section 5.1).

[19] Guide to the 2019 Roadmap for Research Infrastructures (with regard to 2021–2024 ERI planning) Objectives, process and criteria (in French or German)

3.2.2. Procedure

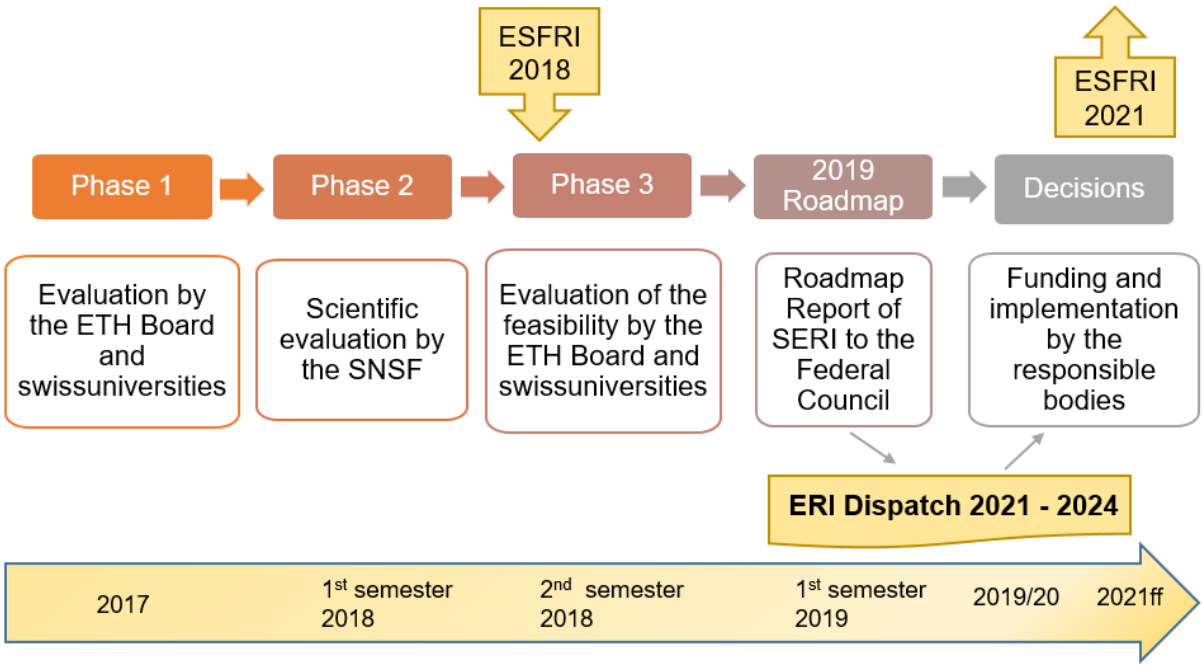

Figure 3.1: Procedure for new national infrastructure projects.

a) Newly planned national research infrastructures

Phase 1: Between January and October 2017, the responsible bodies (swissuniversities and the ETH Board) made an inventory of newly planned RIs (preselection, see section 4).

Phase 2: Phase 2 involved a scientific evaluation (second evaluation stage) by the SNSF of the infrastructures selected during Phase 1, and on the basis of this, the infrastructures were prioritised according to the criteria listed in section 4 of this document. Only those infrastructure projects classed at the highest level (level A) were shortlisted for the next step in the selection procedure. The SNSF's evaluation thus led to a further selection.

Phase 3: The infrastructure projects classed at level A were examined in more detail by the responsible bodies, which examined their feasibility (governance, management, financing). The detailed description of each of these infrastructures can be found in Annex A1.

b) Update of national infrastructures data in the 2015 Roadmap

Current data on the 23 Swiss infrastructures newly planned in the 2015 Roadmap was gathered in July and November 2018 from the institutions responsible (swissuniversities and ETH Board). The updated information can be found in Annex A2.

c) Update of international organisations and ESFRI project data

Current data on international infrastructures and organisations was gathered by SERI and used by the SNSF in its statements (see section 7 and Annex B2).

4. Evaluation phases 1 and 2: survey and evaluation process

4.1. Evaluation process and criteria

The ETH Board and swissuniversities conducted a survey among their respective institutions to collect proposals for new research infrastructure projects, including substantial upgrades. In a first step, the sponsoring institutions (higher education institutions and research institutes in the ETH Domain) submitted rough outlines of the new RIs, and these were assessed in terms of their alignment with the strategic planning of the higher education institutions concerned and with regard to the eligibility conditions set out in section 3.1.

Evaluation result (first evaluation stage): 17 new projects were selected. Commissioned by SERI, the SNSF then assessed 15 of these[20] (second evaluation stage) applying the following criteria:

- Quality of the infrastructure, of the research and the researchers involved;
- Scientific importance;
- Accessibility and user groups;
- Scientific feasibility.

On the basis of the SNSF's evaluation, the infrastructures were classed into three categories:

Priority A	High scientific relevance	7 projects
Priority B	Medium scientific relevance	7 projects
Priority C	Low scientific relevance	1 project

4.2. Overview by field and institution

The 15 RIs reviewed by the SNSF span four main fields of discipline, as follows (Figure 4.1):

- Humanities and social sciences: 3
- Science, technology, engineering and mathematics (STEM): 8
- Life sciences: 3
- E-infrastructures: 1

The following sponsoring institutions submitted new projects:

- ETH Domain: 6
- Cantonal universities: 8
- Universities of applied sciences: 1

The funding volume required for these 15 new projects was estimated at around CHF 708 million (total investment and operating costs for 2021–2024 as at August 2018).[21] Figure 4.2 below shows how these costs are divided up among the four main academic fields, and Figure 4.3 shows the spread between the priority categories A, B and C.

The projects assessed are spread across all fields, with STEM accountable for the greatest number (Figure 4.1). The breakdown of funding by scientific field (Figure 4.2) also clearly shows that STEM accounts for the highest costs. It is notable that there was just one e-infrastructure project, but that this accounted for 24% of the costs. The breakdown of costs into priority categories shows that almost two thirds of the planned costs are attributable to projects in priority category A (Figure 4.3).

[20] Only 15 of the 17 projects were assessed by the SNSF because one ETH Board project was not submitted to the SNSF and one swissuniversities project was withdrawn after being submitted to the SNSF.

[21] This funding requirement was increased, confirmed or reduced following an in-depth financial assessment (third evaluation phase).

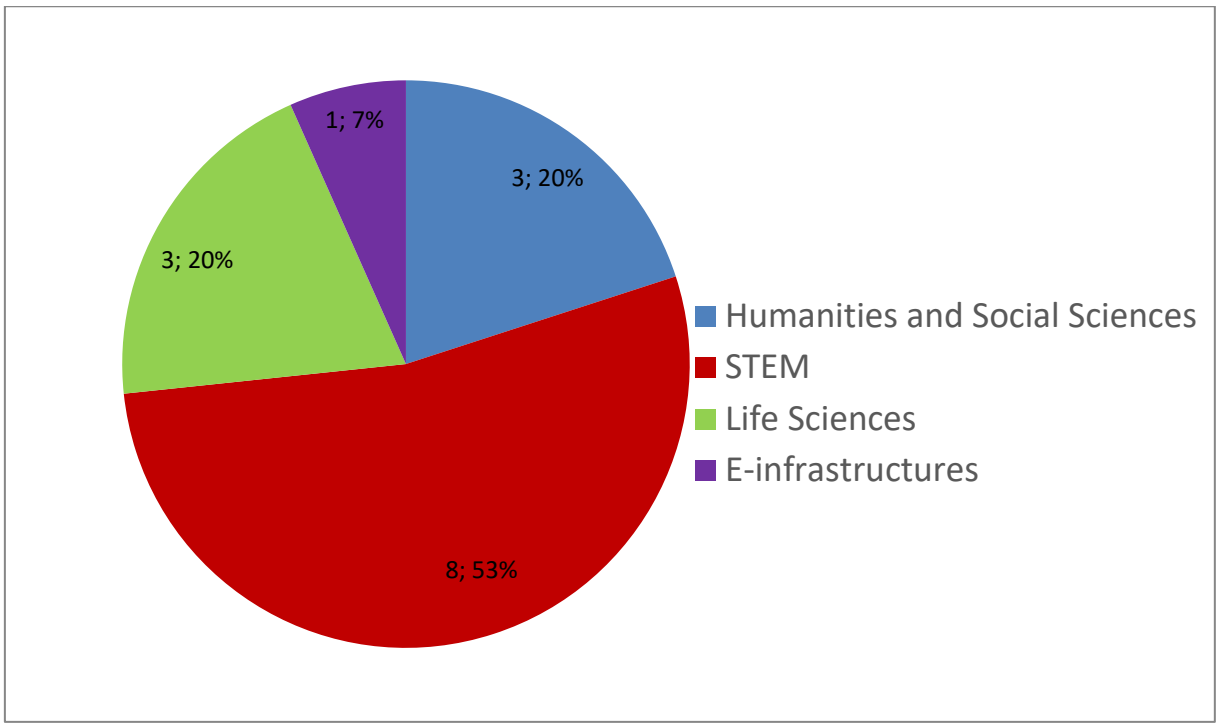

Figure 4.1: Distribution by field (n=15 projects).

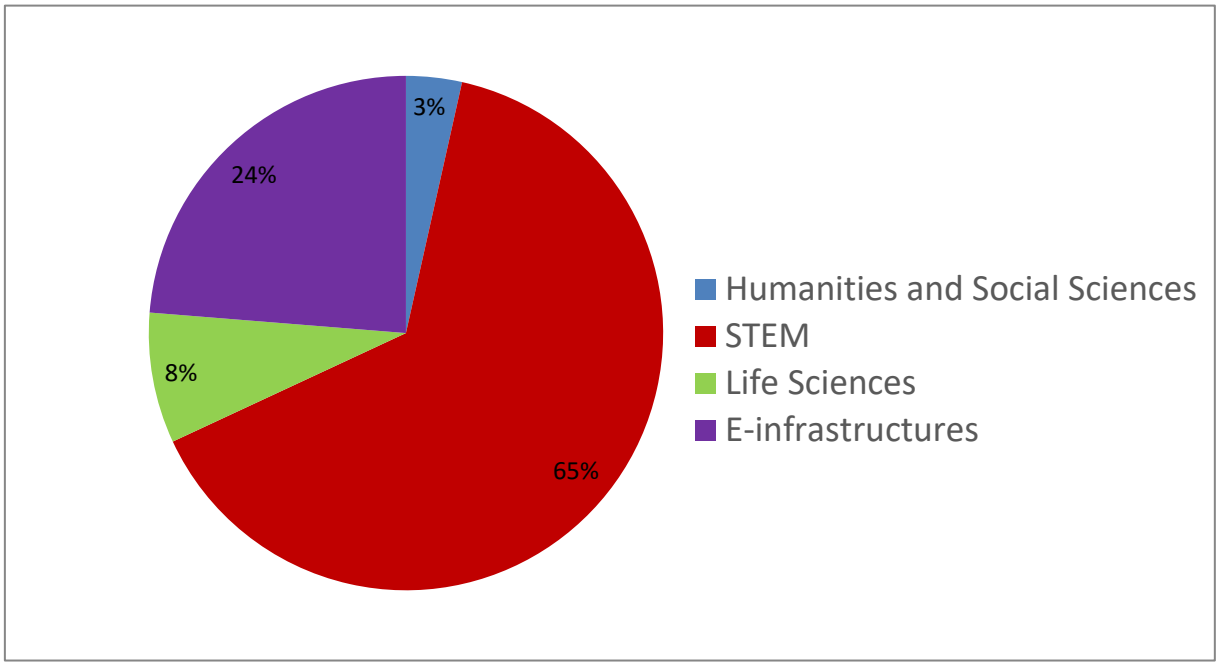

Figure 4.2: Distribution of funds by field (n=15 projects for a total of CHF 708 million).

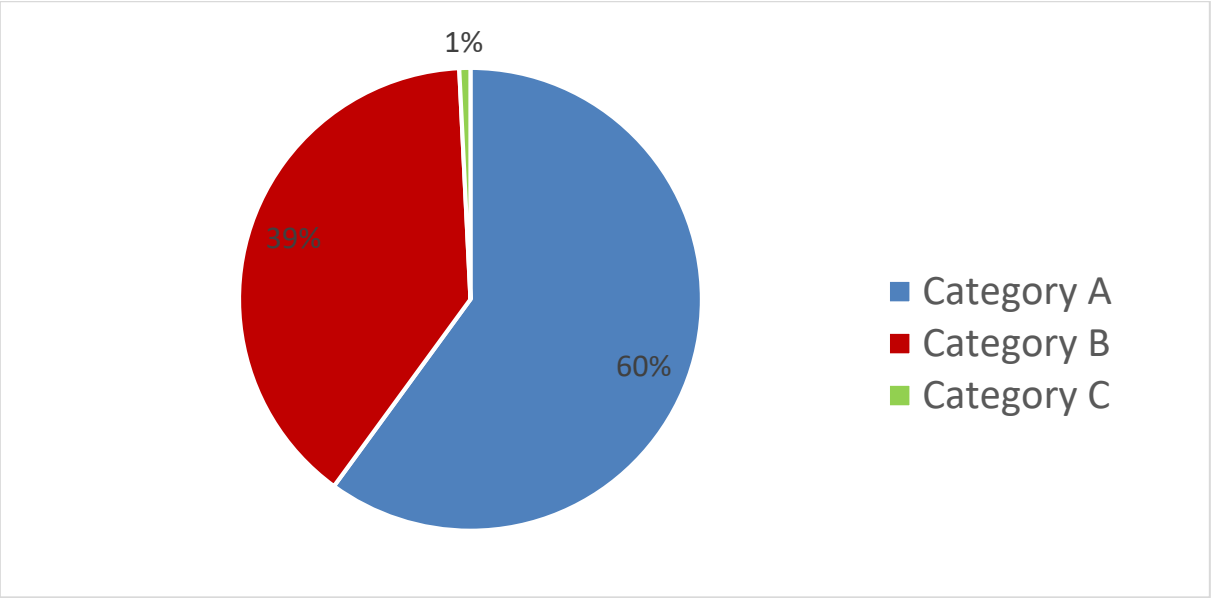

Figure 4.3: Distribution of funds by priority (n=15 projects at a total of CHF 708 million).

5. Evaluation phase 3: evaluation by responsible bodies

5.1. Allocation of tasks

Under the Federal Act on the Promotion of Research and Innovation (RIPA), higher education institutions, or the bodies responsible for them, are primarily responsible for supporting and financing research infrastructures. The Confederation's research funding bodies (the SNSF and Academies) play a subsidiary role in the funding of research infrastructures (Art. 10 para. 3 let. c and Art. 11 para. 6, RIPA). The Confederation's role is to promote research infrastructures of national importance (Art. 15, RIPA) and Switzerland's participation in internationally coordinated RIs if such participation is the subject of an international treaty (Art. 28 RIPA).

Under the Swiss Federal Institutes of Technology Act and in the Federal Council's strategic objectives for the Swiss federal institutes of technology, the ETH Board, the two federal institutes of technology EPFL and ETHZ and the four research institutes (PSI, WSL, Empa and Eawag) are responsible for creating their own research infrastructures (this may also involve third-party funding). Meanwhile, under the Federal Act on Funding and Coordination of the Higher Education Sector (HEdA), the cantonal universities and federal institutes of technology receive subsidiary funding in the form of basic contributions from the Confederation for research infrastructures within their competence. Project-linked funding (Art. 59 para. 2, HEdA) is used primarily to finance for a limited period cooperation projects which are important to the whole of the higher education system and which relate principally to teaching and the programmes offered.

In view of the above, all 15 projects evaluated by the SNSF in Phase 2 fell within the competence of the ETH Board (six projects) or swissuniversities (nine projects including eight projects by cantonal universities and one from a university of applied sciences).

Both the ETH Board and swissuniversities carried out Phase 3 of the evaluation according to its own procedure for projects classed in category A by the SNSF (seven projects in total). Common criteria were used to evaluate planning, governance and management, finances and institutional support.

5.2. In-depth evaluation: feasibility (funding, planning, governance and management) – Results

At the end of Phase 3 of the evaluation, the responsible bodies put forward seven projects classed by the SNSF in Category A (high importance) for an in-depth study of their implementation. Table 5.1 provides an overview of these priority research infrastructures, classed according to financial volume. The total estimated costs for the 2021–2024 period amount to approximately CHF 412.82 million, of which CHF 366.9 million is to be borne by the Confederation (as at January 2019). Figure 5.1 shows the distribution of costs by academic field for the seven recommended projects. It should be noted that e-infrastructures, humanities and social sciences and life sciences each contain only one project, while the STEM domain contains four projects.

Table 5.1: Priority infrastructures and costs for the 2021–2024 period.

Field	Institution	Project	Total costs (CHF m)[22]	Federal costs (CHF m)[23]
E-infrastructures	ETH Zurich	High-Performance Computing and Networking Infrastructure (HPCN-24)	174.00	162.00
STEM	PSI	Swiss Light Source SLS 2.0	167.00	167.00
STEM	EPFL & ETHZ	Catalysis Hub (CAT+)	32.70	31.90
Life sciences	University of Zurich	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	18.00	6.00[24]
STEM	University of Zurich	Airborne Research Facility for the Earth System (ARES)	9.22	-
Humanities and social sciences	University of Zurich	Linguistic Research Infrastructure (LiRI)	6.80	-
STEM	University of Zurich	Center of Structural Electron Microscopy (COSEM)	5.10	-
		Total	**412.82**	**366.9**

Annex A1 of this Roadmap contains detailed descriptions of these proposed research infrastructures.

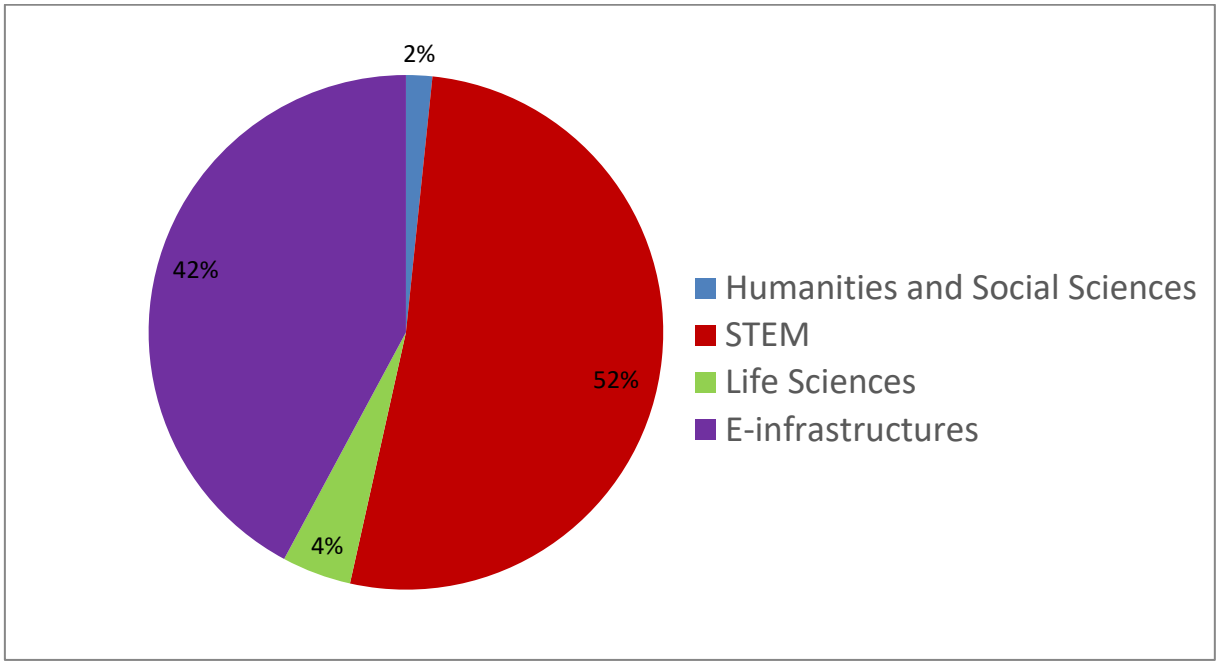

Figure 5.1: Distribution of funds by field (n=7 projects recommended for a total of CHF 412.82 million).

a) ETH Domain (as at January 2019)

In accordance with the ETH Board's planning[25] the research infrastructures shown in Table 5.2 are of particular strategic importance. Having been assessed positively, the three proposed infrastructures listed in this table were recommended by the ETH Board for inclusion in the Roadmap.

[22] The detailed budget can be found in Annex A1.

[23] Federal costs include institutions in the ETH Domain and the ETH Board; SNSF competitive funds (e.g. R'Equip) are not included.

[24] ETHZ contribution.

[25] ETH Board 2021–2024 strategic planning for the ETH Domain.

Table 5.2: ETH Domain priority infrastructures.

No[26]	Research infrastructure	Sponsoring institution	Estimated funding requirement 2021–2024 (CHF m)	Amount met by ETH Domain funding envelope (CHF m)
1	High-Performance Computing and Networking (HPCN-24)	ETH Board (ETHZ)	174.0	162.0
2	Swiss Light Source SLS 2.0	ETH Board (PSI)	167.0	167.0
3	Catalysis HUB (CAT+)	ETH Board (EPFL & ETHZ)	32.7	31.9
		Total	**373.7**	**360.9**

CHF 373.7 million has been earmarked in the 2021–2024 period to set up these three proposed research infrastructures (two upgrades, one new). CHF 360.9 million (of which CHF 216 million is provided by the ETH Board) is to be met from the ETH Domain funding envelope. If the ETH Domain is unable to provide the required funding from the funding envelope yet to be determined by Parliament for 2021 to 2024, the ETH Board will decide at an appropriate time how to fund the projects in accordance with its financial capacities.

In addition to investment in new RIs, substantial resources will be made available in the 2021–2024 period for operating and developing or expanding existing research infrastructures. For instance, in its strategic planning for this period, the ETH Board has earmarked CHF 88 million to develop the EPFL's Blue Brain neuroinformatics project.

Conclusion:

- The three proposed research infrastructures listed above will require CHF 360.9 million in funding from the Confederation (as sponsor of the ETH Domain) in the 2021–2024 ERI period.
- The amount of funding available will be set via the ETH funding envelope in the 2021–2024 ERI Dispatch.
- The ETH Board and institutions in the ETH Domain decide whether these research infrastructures are set up and how much funding they will receive in the 2021–2024 ERI period.

[26] Detailed information can be found in Annex A1. The infrastructures are numbered in the same way as here.

b) Cantonal universities (as at January 2019)

The following four infrastructures were evaluated and approved by swissuniversities as part of the cantonal universities' strategic planning:

Table 5.3: Cantonal universities' priority infrastructures.

No[27]	Research infrastructure	Main sponsoring institution	Estimated funding requirement 2021–2024 (CHF m)	Amount met by Confederation (CHF m)
4	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	University of Zurich	18.00	6.00[28]
5	Airborne Research Facility for the Earth System (ARES)	University of Zurich	9.22	-
6	Center of Structural Electron Microscopy (COSEM)	University of Zurich	5.10	-
7	Linguistic Research Infrastructure (LiRI)	University of Zurich	6.80	-
		Total	**39.12**	**6.00**

An estimated CHF 39.12 million is required to set up and run these four research infrastructures. swissuniversities did not request project-linked funding for any of the proposed RIs.

Conclusion:

- Full realisation of these new proposed research infrastructures would cost the Confederation CHF 6 million (contribution to ETHZ costs for the 1.2 GHz NMR project)
- The cantonal universities decide whether these research infrastructures are set up and how much funding they will receive in the 2021–2024 ERI period.

c) Confederation

The Confederation is not directly responsible for any of the projects in Category A. Requests for infrastructures of national importance (Art. 15 RIPA) are subject to an independent procedure. Applicants are required to submit their proposals by 30 June 2019 (Art. 12 RIPO-EAER, SR 420.111). These proposals will be evaluated by the Swiss Science Council and the final decision made by the EAER at the end of 2020.

[27] Detailed information can be found in Annex A1. The infrastructures are numbered in the same way as here.

[28] ETHZ contribution

6. Research infrastructures funded by federal funding bodies

While the main financial burden of the research infrastructures is shouldered by the higher education institutions, the ETH Domain research institutes and their bodies responsible for funding research infrastructures, the RIPA states that the Confederation's funding bodies (in particular the SNSF and Academies) shall play a subsidiary funding role. The latter have already submitted their planning as part of their 2021–2024 multi-year programmes.

6.1. SNSF

The SNSF usually contributes to RIs financially in the form of specific, earmarked funding for a limited period of time.

In the 2021–2024 period, the SNSF will extend its portfolio to include data infrastructures and repositories of national importance which are essential to scientific research. These infrastructures, which are too expensive for individual institutions to set up and run, will provide valuable services to the science community both in Switzerland and abroad thanks to a transparent access policy and data interoperability.

There are a number of different types of data infrastructure (and repositories), and so it is necessary to define specific evaluation criteria to cover all forms. The SNSF thus proposes the gradual development of its activities in this field during the 2021–2024 period.

From 2021 onwards, the SNSF will be responsible for funding and evaluating the existing FORS and DaSCH infrastructures, and for cohort studies (including the Swiss HIV Cohort Study (SHCS) and Swiss Transplant Cohort Study (STCS), which are of high priority to the Federal Office of Public Health). In general, the cohort studies will be funded via established research funding instruments.

In order to respond to the growing need for specialist data infrastructures (in addition to the existing infrastructures of national importance), the SNSF is intending to introduce start-up grants and development funding for data infrastructures with the potential to be of national importance. Infrastructures that are not considered to be of national importance will be funded for an initial ten years only, in accordance with the SNSF's funding policy for research infrastructures.

The SNSF will also be pursuing the programmes R'Equip (acquisition of large instruments) and FLARE (international research infrastructures in the fields of Particle Physics, Astrophysics and Astroparticle Physics).

During the 2021–2024 multi-year programme, the SNSF intends to support the following programmes and infrastructures:

Research infrastructure	**2021–2024 budget** in CHF m (as in multi-year programme)
a) Instruments	
Research infrastructures and R'Equip	115.1
b) Funding of data infrastructures commissioned by the Confederation (SERI)	
FORS (transfer from Art. 15 RIPA)	32.8
DaSCH (transfer from Academies)	9.2
Data repositories/other activities in data infrastructures[29]	10.0
SHCS and STCS cohort studies	20.0
c) Other funding (platforms)	
SCTO	4.0
Swiss Biobank Platform	4.0
Longitudinal studies (cohort studies)	32.0
Total	**227.1**

Conclusion:

- In addition to existing programmes (e.g. R'Equip), the SNSF will fund data repositories, data infrastructures and cohort studies.
- The SNSF establishes and funds research infrastructures that fall within its responsibility using resources apportioned to it in the 2021–2024 ERI Dispatch (funding envelope).

[29] swissuniversities is requesting CHF 45 million for data repositories under Art. 59 RIPA (project contributions). An inventory of data repositories as required by SERI must be made available, and on this basis the objectives for data repositories in the higher education sector (including the ETHZ's and EPFL's priorities with regard to the national data centre initiative: see Annex A2) must be coordinated with the SNSF's activities. Furthermore, there should complementary use of SNSF and swissuniversities resources earmarked for this purpose (avoiding the creation of parallel structures).

6.2. Academies

In its 2021–2024 multi-year programme, the **SAHS** proposes funding the following research infrastructures with a budget of CHF 59.69 million:

Editions (transfer from SNSF)	CHF 13.15 m
Long-term undertakings (continued)	CHF 46.54 m

In its 2021–2024 multi-year programme, the **SCNAT** proposes funding the following research infrastructures with a total budget of CHF 22.84 million:

Science secretariats (transfer from SNSF)	CHF 8.84 m
Natural sciences collections (new project)	CHF 14.00 m

In its 2021–2024 multi-year programme, the **SAMS** has a budget of CHF 33 million for:

SPHN initiative (continued)	CHF 33.00 m
Total for the Academies	**CHF 115.53 m**

Conclusion:

- Funding for research infrastructures within the Academies' remit is met from the funding envelope awarded to the Academies in the 2021–2024 ERI Dispatch.

7. International research infrastructures

7.1. ESFRI projects whose relevance for Switzerland should be examined

Swiss institutions participate in several ESFRI projects, without the Confederation bearing direct responsibility. These are ESFRI projects that have adopted the ERIC legal form. For these projects Switzerland has requested observer status, which does not entail any commitment under international law. However, the fact of Swiss institutions participating in these ESFRI projects may have consequences for the Confederation's investments in the ETH Domain, for funding for cantonal universities and universities of applied sciences, for contributions under Art. 15 RIPA or for tasks falling within the remit of the SNSF or the Academies.

SERI commissioned the SNSF to produce statements on international infrastructures in which Switzerland is already represented by the institutions concerned. The infrastructures listed below are included in the ESFRI 2018 Roadmap.[30]

In November 2018, the SNSF published statements[31] on the national importance of the following infrastructures: eLTER, SILECS, ECCSEL, ACTRIS, ELI, BBMRI, ECRIN, EPOS, ICOS, CESSDA, ESSurvey, SHARE, DARIAH, EST and PRACE. SERI posed the following questions to the SNSF in order to establish the degree of national importance of each infrastructure:

- To what extent is Switzerland's participation in the international infrastructure indispensable to the scientific community for development in Switzerland?
- Which infrastructures can be classed as A, B or C according to their importance for the scientific community in Switzerland (A: major importance; B: average importance C: minor importance)?

[30] www.esfri.eu/

[31] In these statements, the SNSF stated its position on the importance of international infrastructures for Switzerland. The ESFRI proposals had already undergone scientific evaluation at European level.

a) Infrastructures in which Swiss institutions already participate (2021–2024)

Infrastructure	Principal Swiss institution involved ('national node')	Priority for Switzerland	Approx. federal costs (SERI or SNSF) (CHF m)[32]
European Plate Observing System **(EPOS ERIC)**	ETHZ	A	0.65 (SERI)
European Clinical Research Infrastructure Network **(ECRIN ERIC)**	SCTO	A	0.22 (SERI)
Integrated Carbon Observation System **(ICOS ERIC)**	ETHZ	A	0.32 (SNSF)
Biobanking and Molecular Resources Research Infrastructure **(BBMRI ERIC)**	SBP	A	0.26 (SNSF)
Consortium of European Social Science Data Archives **(CESSDA ERIC)**	University of Lausanne	A	0.13 (SNSF)
European Social Survey **(ESSurvey ERIC)**	University of Lausanne	A	0.43 (SNSF)
Survey of Health, Ageing and Retirement in Europe **(SHARE ERIC)**	University of Lausanne	A	0.10 (SNSF)
Partnership for Advanced Computing in Europe **(PRACE)**	ETHZ	A	-
European Carbon Dioxide Capture and Storage Laboratory Infrastructure **(ECCSEL ERIC)**	ETHZ	A	0.26 (SERI)

b) Infrastructures in which Swiss institutions have shown an interest

Infrastructure	Swiss institutions involved ('national node')	Priority for Switzerland	Approx. costs to Confederation (SERI) (CHF m)[33]
Aerosol, Clouds, and Trace Gases Research Infrastructure **(ACTRIS)**	PSI	A	5.09[34]
Digital Research Infrastructure for the Arts and Humanities **(DARIAH ERIC)**	Consortium[35]	A	To be established (SNSF)
European Long-Term Ecosystem and socio-ecological Research Infrastructure **(eLTER)**	WSL, ETHZ, University of Basel	A	-
Extreme Light Infrastructure **(ELI)**	ETHZ	B	-
European Solar Telescope **(EST)**	USI[36]	B	-
Infrastructure for Large-scale Experimental Computer Science **(SILECS)**[37]	University of Geneva	B-C	-

Twelve infrastructures were considered to be of major importance for the Swiss science community (Priority A). Of these, two are at the planning stage (ACTRIS and eLTER) and one does not yet have any Swiss participants (ECCSEL ERIC). The SILECS, EST and ELI infrastructures do not have top

[32] Participation costs.
[33] 2021–2024 period.
[34] This figure also includes a request from the institutions (primarily the ETHZ) to participate in activities under ACTRIS.
[35] Consortium comprising the universities of Basel, Bern, Geneva, Lausanne, Neuchâtel and Zurich, the EPFL and the SAHS.
[36] Università della Svizzera italiana.
[37] It was proposed that SILECS (coordinated with France) should feature in the 2018 ESFRI Roadmap but it was not selected.

priority status (Priority B/C). Only international infrastructures with Priority A are looked at in more detail and described in Annex B1.[38]

Conclusion:

- In the context of the 2021–2024 ERI Dispatch, SERI will examine the possibility of Switzerland's participation in Priority A international infrastructures. In doing so it will take into account the opinions of the SNSF as well as national and international policy and financial aspects (available funds).
- The cost of participating in an ESFRI infrastructure is met by the universities themselves (in cash and in kind) and by subsidiary federal funding of CHF 6.22 million francs provided by SERI and a further CHF 1.24 million provided by the SNSF (as part of the global budget made available in the 2021–2024 ERI Dispatch).

c) 2018 ESFRI Roadmap update

Since the last edition of the Swiss Roadmap in 2015, new infrastructures projects in which Swiss institutions have shown an interest have been integrated into the European ESFRI Roadmap.

- Existing research infrastructures (not yet an ERIC):
  - **ACTRIS:** In the 2015 Swiss Roadmap, the Swiss research community expressed an interest in participating in this research infrastructure. SERI duly investigated and obtained the opinion of the SNSF, and on this basis it was decided to examine Switzerland's possible participation in ACTRIS during the next ERI period, and to postpone the question of membership, most likely until 2024 or 2025 (when the ERIC is due to be established). ACTRIS is coordinated by the PSI and co-financed by a consortium of higher education institutions and research institutes.
  - **EST**: Following investigations by SERI and taking account of the SNSF's opinion, it was decided not to pursue the option of participating in EST at the current time.

- Furthermore, the Swiss research community expressed an interest in the eLTER research infrastructure recently integrated into the 2018 ESFRI Roadmap and described below:
  - **eLTER** (in the ESFRI Roadmap since 2018): In the 2015 Swiss Roadmap, the Swiss research community expressed an interest in taking part in this RI. Following investigations by SERI and taking account of the SNSF's opinion, it was decided to evaluate Switzerland's possible participation in eLTER during the next ERI period and that the question of membership would be posed in 2025 (when an ERIC will be established). eLTER will be coordinated by the WSL and jointly funded by the WSL, the ETHZ and the University of Basel.

7.2. International research organisations and infrastructures in which Switzerland is a member at government level

Contributions to international research organisations and infrastructures in which Switzerland is a member at government level are compulsory under international law and are thus restricted funds. The figures are submitted to Parliament each year when the state budget is drawn up. This procedure concerns the following international research infrastructures: CERN, ESO, EMBC/EMBL, ESRF and European XFEL.

However, when infrastructures in this category are in the planning or construction phase, Swiss funding comes from monies earmarked in the ERI Dispatches (European Spallation Source ERIC, CTA) or the dispatch on Switzerland's participation in the EU Framework Programmes (ITER/Fusion for Energy). Funding for infrastructures in which Switzerland's participation is limited to a fixed period (ILL) is also requested in the ERI Dispatch.

[38] ELI was already under examination during the 2017–2020 period and in its statement the SNSF did not recommend discontinuing this process. This infrastructure is therefore also described in Annex B1.

Developments relating to these infrastructures in the 2017–2020 period have given rise to the following requirements in the 2021–2024 period:

- Extend Switzerland's participation in ILL until the European Spallation Source ERIC is up and running and possibly beyond (see table in Annex B2);
- Contribute to additional construction costs of the European Spallation Source ERIC (CHF 32 million for 2021–2024) and of ITER/Fusion for Energy (CHF 110 million for 2021–2024);
- As a founding member, participate in the establishment of the CTAO ERIC (CHF 10 million for 2021–2024);
- Rejoin the SKA infrastructure (CHF 9 million for 2021–2024).

These amounts will be requested (subject to Federal Council decisions) in the 2021–2024 ERI Dispatch or in the EU Dispatch on Switzerland's participation in the EU Framework Programmes. CTA and SKA were among the four infrastructures in this category identified in the 2015 Roadmap which had to examined specifically in the 2017–2020 period.

It was decided that the other two infrastructures, ELI and LBNF-DUNE, should not receive funds from the ERI budget in the 2021–2024 period. However, these two infrastructures will continue to be considered during the next funding period with a view to including them in the 2025–2028 ERI Dispatch, along with the infrastructures in section 7.1.

A table showing details of the costs can be found in Annex B2.

8. Conclusion and outlook

The research infrastructures proposed in this 2019 Roadmap reflect the planning status at the end of March 2019.

The EAER (SERI) is required to consider the funding bodies' multi-year programmes which feature in the 2019 Swiss Roadmap and to submit to the Federal Council with the 2021–2024 ERI Dispatch its proposals for the implementation of infrastructures, taking into account the ERI funding available.

As a planning instrument, the Roadmap offers an overview of the newly planned research infrastructures and an update of projects selected in the 2015 Roadmap. Furthermore, it serves as a basis for the coordination necessary between the planning of national research infrastructures and that of European RIs (ESFRI Roadmap) and international RIs.

However, this Roadmap does not contain any decision on the amount or allocation of any federal monies earmarked in the 2021–2024 ERI Dispatch. With regard to the cantonal universities, the Confederation provides subsidiary and indirect support for infrastructures under the Higher Education Act (HEdA). In the ETH Domain, the ETH Board, the two federal institutes of technology ETHZ and EPFL, and the four research institutes are responsible for setting up and running their own research infrastructures under the Swiss Federal Institutes of Technology Act and the Federal Council's strategic objectives for the ETH Domain. With regard to RIs featuring in the multi-year planning of the research bodies, the running and funding of projects is decided in accordance with the Confederation's funding for the SNSF and Academies. The Confederation is responsible for Switzerland's participation in international (European) research infrastructures.

The amount of federal monies will be set by Parliament in the context of the 2021–2024 ERI Dispatch – taking into consideration the ETH Domain's funding envelope, funding awarded under HEdA, funding for the research bodies and funds for international cooperation.

In preparation for the next Roadmap in 2023, SERI and its partners will examine the process and adapt it accordingly.

9. Glossary

Abbreviation	Meaning
EAER	Federal Department of Economic Affairs, Education and Research
Eawag	Swiss Federal Institute of Aquatic Science and Technology (ETH Domain)
Empa	Swiss Federal Laboratories for Materials Science and Technology (ETH Domain)
EPFL	Federal Institute of Technology Lausanne
ERI	Education, research and innovation
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ETHZ	Federal Institute of Technology Zurich
ETH, EPF	Federal institute of technology
HEdA	Federal Act on Funding and Coordination of the Higher Education Sector, SR 414.20
MYP	Multi-year programme
PSI	Paul Scherrer Institute (ETH Domain)
RI	Research infrastructure
RIPA	Federal Act on the Promotion of Research and Innovation, SR 420.1
SAHS	Swiss Academy of Humanities and Social Sciences
SAMS	Swiss Academy of Medical Sciences
SCNAT	Swiss Academy of Sciences
SERI	State Secretariat for Education, Research and Innovation
SNSF	Swiss National Science Foundation
SSC	Swiss Science Council
swissuniversities	Swiss Conference of Rectors of Higher Education Institutions (in accordance with HedA)
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research (ETH Domain)

2019 Swiss Roadmap for Research Infrastructures

Annex A

Annex A1: New (or substantially upgraded) national infrastructure projects in the 2019 Roadmap

NB:

1) **The financial information given below reflects the planning figures provided by the higher education institutions/infrastructure management.**
2) **The financial figures in this document for the ERI periods 2021–2024 and 2025–2028 are forecasts and are only given as a rough estimate of probable future costs and how these will be allocated.**
3) **Last information update: January 2019**

1. High-Performance Computing and Networking (HPCN-24)[39]

Category: E-infrastructure

Host institution(s): ETH Zurich

Main funding sources: ETH Board, ETH Zurich

Description / Development prospects

a. National level

Overview

The Swiss National Supercomputing Centre (CSCS) in Lugano develops and operates an open access research infrastructure for extreme-scale scientific computing, which is also referred to as supercomputing. This research infrastructure is a User Lab, the resources of which are accessed openly and managed in a transparent, peer-review process. There are two tiers of allocations. Researchers from all over the world can apply for Tier 1 projects for requests of up to one million node-hours p.a., which are allocated by a panel of eminent, international scientists, and Tier 0 allocations for very large projects that require more than one million node-hours p.a. The launch of Tier 0 calls and subsequent proposal screening is managed by the Partnership for Advanced Computing in Europe (PRACE), of which Switzerland is a member represented by ETH Zurich. The two review processes have a similar structure. Furthermore, several Swiss academic institutions and research projects benefit directly from the economies of scales reached by CSCS thanks to the User Lab.

In 2019, the CSCS User Lab is among the globally leading research infrastructures of its kind. For this to be still true in five to ten years, the supercomputing systems will have to be renewed regularly. Specifically, the current flagship supercomputer Piz Daint will have to be replaced by 2022. This major infrastructure upgrade comes at a time when Moore's Law, the main engine for performance enhancements in supercomputing since the 1970s, is tapering off and the industry appears to be supply-limited (i.e. prices are increasing). This will lead to continuing architectural diversification and increasing complexity in the use of supercomputers.

Detailed description

Fortunately, CSCS, with its established application-driven co-design approach to the development of supercomputers, along with Swiss-based researchers, who have contributed to application development projects funded by the Platform for Advanced Scientific Computing (PASC), are in a very strong position to tackle these technological challenges in the coming decade. Our plan builds on this experience and will provide Switzerland (and science in general) with a technologically advanced and very capable supercomputing infrastructure. It will not be the largest in terms of peak floating-point performance, but one of the most productive in terms of application performance and productivity.

The design of the supercomputer to replace Piz Daint will be based on very ambitious performance goals for next generation simulations of weather and climate. Choosing a single domain will result in an architecture that will be usable in many other domains but focusing the design on one enables us to set clear goals for ambitious design goals and to define consistent success metrics.

The build-up of the successor to Piz Daint began in 2018 with site preparation. A test and development system will be installed in late 2019 and the actual system will start to be brought onsite in 2020. A rigorous evaluation of node architectures with all processor options began in 2018 and will continue until 2020. Full scale-out of the system will be started in late 2021 and is expected to be completed in 2022. Operations will begin in 2023 and run until at least 2028. An upgrade of the compute nodes is anticipated for 2026.

b. International level

All User Lab resources are accessible to all scientists, irrespective of the country they are based in, and allocation decisions are taken purely on the basis of a transparent peer-review-based process. From a

[39] This infrastructure was already listed in the 2015 Roadmap for Research Infrastructures (upgrade for the 2019 Roadmap for Research Infrastructures).

European perspective, about 40% of the resources are allocated via the Tier 0 programme of PRACE, in which Switzerland is one of the leading partners.
The software strategy for weather and climate builds on domain-specific libraries (DSL), technologies developed by CSCS and ETH Zurich, which will support major European models such as IFS of the European Centre for Medium-Range Weather Forecasts or the ICON model developed by the Max Planck Institute for Meteorology and the German Weather Service (DWD), as well as the leading US model FV3 developed by the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton.

c. Development prospects

Computing technologies have to be continually renewed, even in the post Moore's Law era. For this reason, the Swiss High-Performance Computing and Networking (HPCN) initiative, which funds both the User Lab at CSCS as well as PASC, consists of a long-term funding envelope for investments and a long-term commitment by ETH Zurich to fund the User Lab operations. This funding envelope is flat, despite the fact that prices for computing technologies have been increasing substantially in recent years (end of Moore's Law and supply-limited market). Experience at CSCS over the past 10 years has shown that price hikes could be mitigated through active pursuit of new technologies – CSCS was one of the first computing centres worldwide to introduce GPU technologies. During the next phase, the replacement of Piz Daint by 2022, much of the needed performance increase will come from investments in software that are mostly funded with national and international contributions outside of the current HPCN initiative. The subsequent upgrade that is planned for the 2025–2028 time period will certainly build on these continued investments in software. However, it is entirely possible that fundamentally new processor architectures will be available by that time, which could boost simulation performance substantially – such technologies are being developed at ETH Zurich in collaboration with industry. Of course, it is also possible that such technologies will not develop as expected and that the necessary performance increases can only be achieved by expanding the infrastructure's footprint. With such a scenario, costs will go up and the business and funding model of the infrastructure will have to be reconsidered. In 2019, it is too early for such decisions, so we continue to work with a flat funding envelope.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution Universities PASC: 6 m	Higher Education Institution Universities PASC: 6 m	Higher Education Institution Universities PASC: 6 m
Canton 0	Canton 0	Canton 0
Swiss Confederation ETH Board: 92 m ETH Zurich: 64 m ETH Zurich PASC: 6 m	Swiss Confederation ETH Board: 92 m ETH Zurich: 64 m ETH Zurich PASC: 6 m	Swiss Confederation ETH Board: 92 m ETH Zürich: 64 m ETH Zurich PASC: 6 m
Third parties PRACE AISBL & IP: 6 m	Third parties PRACE AISBL & IP / EuroHPC: 6 m	Third parties PRACE AISBL & IP / EuroHPC: 6 m
Total budget **174 m**	**Total** **174 m**	**Total** **174 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 80 m Operating costs 70 m Other costs 24 m	Investments 80 m Operating costs 70 m Other costs 24 m	Investments 80 m Operating costs 70 m Other costs 24 m
Total costs **174 m**	**Total** **174 m**	**Total** **174 m**

Development Phases	Years
Design	2018–2020
Preparation	2020–2021
Implementation	2021–2022
Operation	2023–2028 ff

2. Swiss Light Source SLS 2.0[40]

Category: Instrument

Host institution(s): PSI

Main funding sources: ETH Board, PSI

Description / Development prospects

a. National level

Overview

The Swiss Light Source (SLS), operational since 2001, has remained one of the leading examples of third-generation storage-ring technology for more than a decade. However, the increasing scope and impact of the uses of synchrotron light sources in almost all areas of the natural and engineering sciences, improvements in source and instrument technology generally, and the advent of diffraction-limited storage-rings (DLSRs) in particular, mean that the SLS must undergo a comprehensive upgrade to remain competitive and attract cutting-edge science.

SLS 2.0 will provide a dramatic increase in brightness (up to a factor of 50) by replacing the current magnet lattice of the storage ring by a new multi-bend achromat (MBA) magnet structure. This, combined with advanced hardware and instrumentation, will enhance the performance of all techniques currently practiced at the SLS by up to three to four orders of magnitude in some cases, while heralding on the one hand new and game-changing sources and on the other, new and innovative techniques. SLS 2.0 is perfectly aligned with the ETH Domain initiatives in advanced manufacturing, personalised health and related technologies, and energy and data sciences.

SLS 2.0 will complement Swiss users' access to the European Synchrotron Radiation Facility (ESRF), an international research organisation based in Grenoble of which Switzerland is a member.

Detailed description

The upgrade focuses on the transformation of the storage ring lattice to MBA technology and the upgrade of the beamlines and end stations to take full advantage of the increased brightness of the machine. The upgrades of the accelerator and the beamlines and PSI's leadership in development of complementary technology (e.g. insertion-device design, pixelated x-ray detectors, x-ray optics) will yield unique research opportunities especially in imaging, diffraction, and spectroscopy, areas in which SLS presently is a leading player:

- In x-ray ptychography (a microscopic technique pioneered at SLS) it will be possible to collect images in seconds or minutes instead of hours.
- SLS is among the leaders in x-ray tomography, resulting in benefits to clinical medicine as well as fundamental and applied sciences. SLS 2.0 will generate more brilliant as well as harder x-ray beams with a larger penetrating power, allowing static and time-dependent tomography for a much larger range of systems.
- The smaller beam produced by SLS 2.0 will enable analysis of sub-micrometre scale protein crystals, a feature currently not achievable at SLS.
- SLS houses the world's premier beamlines for imaging electron states in devices, both buried and at surfaces, and in novel materials. SLS 2.0 will enable collection of such images for small devices of current and future technological importance.

SLS 2.0 will perfectly complement the new x-ray free-electron laser SwissFEL: SLS 2.0 will focus on high (spatial) resolution imaging and spectroscopy at slow time scales (ps to ms) whereas SwissFEL will place emphasis on ultrafast (fs) time domain experiments.

[40] This infrastructure was already listed in the 2015 Roadmap for Research Infrastructures (upgrade for the 2019 Roadmap for Research Infrastructures).

b. International level

The first DLSR at MAX-IV in Lund, Sweden, came on line in Summer 2016. Sirius in Campinas, Brazil, is expected to follow early in 2019, while the ESRF began its upgrade to DLSR-status in December 2018 and plans to host its first users in 2020. The ALS in Berkeley is commencing an upgrade programme that should be finished shortly after projected completion of SLS 2.0. The small footprint of the SLS building has driven entirely novel technical developments, including longitudinally-graded dipoles and reverse bends. With these innovations, SLS 2.0 will offer brilliances comparable to or better than almost all leading worldwide facilities.

c. Development prospects

The SLS upgrade will on the one hand significantly enhance the quality and in many cases also the speed of existing experimental methods, and on the other, herald entirely innovative techniques in areas as diverse as advanced manufacturing, drug design, and electronic-device manufacturing and characterisation. This will have a game-changing impact on both Swiss and international basic research and on Swiss industry. It is thus of utmost importance that the SLS upgrade programme propels PSI back to the forefront of cutting-edge science for the coming two decades. In addition, and as a key element of PSI's basic mission, continuous upgrades of both the machine and endstations will be performed during the operating phase in order to ensure our long-term competitiveness.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation PSI: 2 m	Swiss Confederation ETH Board: 99 m PSI: 68 m	Swiss Confederation PSI: 29 m
Third parties 0	Third parties 0	Third parties 0
Total budget **2 m**	**Total** **167 m**	**Total** **29 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0 Operating costs 0 Other costs 2 m	Investments 116 m Operating costs 0 Other costs 51 m	Investments 9 m Operating costs 0 Other costs 20 m
Total costs **2 m**	**Total** **167 m**	**Total** **29 m**

Development Phases	Years
Design	2017–2021
Preparation	2019–2023
Implementation	2021–2024
Operation	2024

3. Catalysis Hub (CAT+)

Category: Technical infrastructure

Host institution(s): ETH Zurich and EPF Lausanne

Main funding sources: ETH Board, ETH Zurich, EPFL, SNSF, EU

Description / Development prospects

a. National level

Overview

The Catalysis Hub (*Catalysis Hub – Cat+*) provides a unique integrated research infrastructure for the efficient discovery of catalytic technologies for sustainable conversion processes and energy research. This Open Swiss platform, co-headed by the EPFL and ETHZ, will be an open-access facility for catalysis research devoted to the discovery, characterisation and testing of large numbers of homogeneous and heterogeneous catalysts and catalytic processes based on high-throughput experimentation, computations and advanced data analysis.

Detailed description

The Catalysis Hub – *Cat+* is designed as an open-access facility for catalysis research. It will be devoted to the discovery, the characterisation and the testing of large numbers of homogeneous and heterogeneous catalysts and catalytic processes. This requires an integrated workflow, with the fully automated synthesis, characterisation and evaluation of molecular and solid catalysts that will be augmented by advanced integrated computational modelling and data analysis through machine learning – artificial intelligence approaches. This world-leading Catalysis Hub (*Catalysis Hub – Cat+*) will build on the assets of the ETH Domain and will provide the entire Swiss academic and industrial community with access to state-of-the-art and next-generation equipment for catalyst and reaction discovery as well as process optimisation. Cat+ will also provide advanced and operando spectroscopy tools and methods to drive rational design and to understand how to overcome limitations with respect to catalyst deactivation. The Cat+ will group leading experts of every required aspect for catalyst discovery and development. Access to the hub will be secured by rapid online submission and evaluation of proposals followed by task implementation by an efficient team of experts in close collaboration with the applicant research group.

Physically, *Cat+* will be distributed across two main campuses depending on the specific expertise to allow for an efficient dissemination within Switzerland: the East Campus (ETH Zurich/Empa) and West Campus (EPFL) of the *Catalysis Hub – Cat+* will focus on heterogeneous and molecular catalysts, respectively.

b. International level

Efficient catalytic technologies are a recognised tool to address the needs of sustainable chemical production and energy storage/conversion. In this respect, top-level research and teaching institutions worldwide are investing significantly in dedicated catalysis research centres to advance the catalyst discovery and development process. Cat+ will ensure that the ETH Domain and Switzerland as a whole have access to the necessary infrastructure and provide the platform necessary to promote talent and to stay competitive on a global level. Cat+ is open to Swiss academics and industries, and also welcomes international participations and seeks exchange with other leading centres in order to advance the state of the art in catalysis research.

c. Development prospects

The key aim for Cat+'s initial years is to provide the appropriate next generation infrastructure equipment for all aspects of catalyst discovery and development and pair it with the best available experts in the ETH Domain. This unifying approach will allow the centre to react efficiently to the challenges of future catalysis research and sustainable development. Beyond 2025, we expect that the majority of the Cat+ users will be able to fund their use of the infrastructure on a pay-per-use basis. Additionally, we expect significant industry interest in the long term once the full potential of Cat+ is unlocked. Together these

factors should allow transition to a sustainable model ensuring long-term perspective and later upgrades of Cat+.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation ETH Board: 25 m ETH Zurich, EPFL: 6.9 m	Swiss Confederation ETH Board: 9.2 m ETH Zurich, EPFL, others: 3.0 m
Third parties 0	Third parties SNSF, EU: 0.5 m Private sector: 0.3 m	Third parties SNSF, EU: 1.4 m Private sector: 0.8 m
Total budget **0**	**Total** **32.7 m**	**Total** **14.4 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0 Operating costs 0 Other costs 0	Investments 20.2 m Operating costs 6.7 m Other costs 5.8 m	Investments 5.8 m Operating costs 6.7 m Other costs 1.9 m
Total costs **0**	**Total** **32.7 m**	**Total** **14.4 m**

Development Phases	Years
Design	2019–2020
Preparation	2020–2021
Implementation	2020–2022
Operation	2023 ff

4. Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)[41]

Category: Instrument

Host institution(s): University of Zurich, ETH Zurich, University of Basel

Main funding sources: Cantonal funding, ETHZ

Description / Development prospects

a. National level

Overview

A national facility for ultrahigh-field solution NMR spectroscopy will be established to propel the excellent position of Switzerland as a leading country in NMR spectroscopy. This national facility will be located in a new building located at the University of Zurich's Irchel Campus, operated by the university's Department of Chemistry and steered by the three partnering institutions. Funding for the new platform will originate from University of Zurich, ETH Zurich and the University of Basel. The facility will be open to all academic research groups in Switzerland and to participating industrial partners. Data from the new spectrometer are expected to greatly benefit biomedical research in Switzerland.

Detailed description

The 1.2 GHz NMR instrument will provide a major increase in experimental sensitivity and resolution for the analysis of biomolecules. The magnet uses a novel breakthrough technology – high-temperature superconducting coil materials – to achieve a major technological advance. The resulting reduction in required sample concentrations and the larger achievable molecular sizes will significantly extend the applicability of solution NMR spectroscopy to highly challenging and important biomolecular systems. These are studied by the applicant groups and many other Swiss research groups. Applications will encompass studies of structure, function, dynamics and folding of biomacromolecules including, but not limited to, integral membrane proteins, membrane protein complexes, pathogenic bacterial systems, large molecular machines, protein–RNA complexes, and medically relevant drug targets. Further applications are the development of drugs and of new high-resolution NMR methods. The generated data will provide key insights into fundamental biological mechanisms such as protein biogenesis, signalling, allosteric regulation, catalysis, RNA regulation and splicing, as well as epigenetics in normal and disease-causing biomolecular systems.

Many biologically relevant targets are in a size range that benefits substantially from the increased sensitivity of ultrahigh-field NMR instruments. Research in the biomedical area is highly competitive in Switzerland, and access to a 1.2 GHz spectrometer will strengthen research in that field. Moreover, it will help to recruit top scientists working in the above-mentioned biomedical areas to Swiss universities or research institutions.

Currently, NMR centres in Switzerland exist at the ETH Zurich (500–900 MHz), University of Basel (500–900 MHz), EPFL (400–800 MHz) and University of Zurich (500–700 MHz).

b. International level

In Europe, large NMR centres are located e.g. in Berlin, Frankfurt, Göttingen, Munich, Florence, Grenoble, Lyon, Gif-sur-Yvette, Lille, Utrecht, Nijmegen, Oxford, Cambridge, Birmingham, Gothenburg, Copenhagen, Brno and Ljubljana.

Outside of Europe, large NMR facilities exist in the US, Canada, Japan, China, Australia, Brazil, India, Russia, Saudi-Arabia and Taiwan. With the equipment currently installed, Switzerland is at the global forefront in solution Bio-NMR.

The situation will, however, potentially change with the availability of 1.2 GHz solution NMR instruments. Several such machines have already been ordered by research institutions in Germany (Munich, Berlin,

[41] This infrastructure was already listed in the 2015 Roadmap for Research Infrastructures (upgrade for the 2019 Roadmap for Research Infrastructures).

Frankfurt, Göttingen, Jülich), the Netherlands (Utrecht), Italy (Florence), France (Lille), the United States (Memphis), Great Britain and Korea.

The Swiss National Ultrahigh-Field Solution NMR Facility will also seek to develop ties to the INSTRUCT programme in Structural Biology in the European Strategy Forum on Research Infrastructures (ESFRI) in order to foster scientific exchange.

c. Development prospects

Solution NMR has played a major role in structural biology solving structures of many < 30 KDa proteins. It has been extensively applied to probe for interactions between drugs and their receptors, and has thereby critically contributed to the development of many drugs. NMR is additionally capable in a unique way of investigating the dynamics of biomolecules, a property that is at the heart of enzymatic function. This subject is an area of extensive present research and will continue to be of utmost importance even when most structures or folds have been discovered. For example, ground-breaking work has been performed on the function of the ribosome, the proteasome megadalton protein assembly involved in protein degradation, the entire catalytic cycle of dihydrofolate reductase, a pharmaceutically highly relevant protein, or on so-called G-protein coupled receptors, membrane proteins that present targets for most drugs. Novel developments in structural biology also include combinations of NMR and cryo-electron microscopy (cryo-EM) or small-angle X-ray scattering (SAXS) to resolve structures of very large protein-protein or protein-nucleic acid complexes. NMR is particularly suitable to determine folds of proteins that contain large unfolded parts. A class of pathogenic proteins that are of high medical importance are those involved in neurodegenerative diseases, many of which belong to the intrinsically unfolded proteins (IDPs). For all the above-mentioned systems, access to ultrahigh-field NMR spectrometers will be crucial.

Biomedical research is now moving into the systems biology field, in which interactions between complex biomolecular systems become relevant. Again, the systems will be much more amenable to a detailed analysis with data of increased resolution as available from a ultrahigh-field NMR spectrometer.

Finally, the hardware developments are made by a market-leading Switzerland/Germany based company. Investigating high-end products will thus motivate further developments and research in this cutting-edge technology and help secure Switzerland's role as a major player in high-tech industry.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution UniBas/UZH: 11.0 m	Higher Education Institution 5.0 m
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation ETH: 6.0 m	Swiss Confederation 0
Third parties 0	Third parties SNSF: 1.0 m	Third parties 0
Total budget **0**	**Total** **18.0 m**	**Total** **5.0 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0 Operating costs 0 Other costs 0	Investments 16.0 m Operating costs 2.0 m Other costs 0	Investments 1.0 m Operating costs 4.0 m Other costs 0
Total costs **0**	**Total** **18.0 m**	**Total** **5.0 m**

Development Phases	Years
Design	2017–2020
Preparation	2020–2021
Implementation	2022–2023
Operation	2023–2028 ff

5. Airborne Research Facility for the Earth System (ARES)[42]

Category: Integrated Research Infrastructure

Host institution(s): University of Zurich

Main funding sources: UZH, ETHZ, EPFL, Empa, Eawag, UniL, UniFR, private foundations

Description / Development prospects

a. National level

Overview

The Airborne Research Facility for the Earth System (ARES) is an integrated research infrastructure to measure terrestrial processes of the Earth system at regional scale. Data from complementary remote sensing instruments are assimilated in models within a dedicated computing infrastructure. The tight integration of state-of-the-art sensors with sophisticated models through a computing infrastructure will be unique within Switzerland and Europe, delivering world-class data and science output to the Earth System Science community, fostered by a FAIR (findable, accessible, interoperable, and reusable) infrastructure with an open-access data policy. ARES will be available primarily for Swiss researchers to collect data in Switzerland. As an open platform, it will also be made available to researchers on an international level to optimise the system usage through deployments outside of Switzerland.

Detailed description

The integrated research infrastructure Airborne Research Facility for the Earth System (ARES) is composed of three components as follows:
High-precision Earth observing instruments mounted on an airborne platform measure the electromagnetic spectrum reflected and emitted from the Earth's surface. The complimentary instruments comprise (a) an imaging spectrometer, (b) a multispectral laser scanner, and (c) a photogrammetric camera. These sensor systems are interfaced by high precision navigation and position instrumentation for automated data acquisition and geometric processing.

Data acquired by the various instruments are processed to traceable physical units in dedicated processing chains and then assimilated by Earth System models to provide indicators describing the key chemical, biological, structural, geometrical and physical properties of the rapidly changing environment.

The computing infrastructure will be based on existing data centres, upgraded to support ARES data storage, processing and querying to allow the efficient parameterisation of Earth System models. Data analysis, traceability and reproducibility are enabled through consistent metadata including provenance. These will be key to enhance the scientific impact of ARES through open data access. The availability of spatially co-registered, temporally coherent ARES products will enable scientists to explore as yet unknown interactions between Earth System processes using big data approaches.

So far the ARES team has partially been using the Airborne PRISM Experiment (APEX, http://www.apex-esa.org) instrument. APEX is a joint development by the University of Zurich (CH) and VITO (Be) under the framework of ESA PRODEX. APEX reached end-of-life in 2017. The University of Zurich has successfully negotiated a cooperation agreement with NASA Jet Propulsion Laboratory (JPL, Pasadena, CA, USA) to fly their AVIRIS-NG instrument in a transition period (2018–2023), if needed. A first successful deployment of AVIRIS-NG in Europe took place in 2018. Further, the University of Zurich signed a Space Act Agreement (SAA) with NASA JPL in December 2018 to jointly develop a new generation imaging spectrometer (Compact Wide Field-of-View Imaging Spectrometer II (CWIS-II)). CWIS-II will be the first instrument used for ARES.

With a planned upgrade in 2021–2024, the airborne imaging spectrometer will be complemented by a single-photon waveform laser (airborne laser scanner) and a high resolution panchromatic camera. ARES is due to acquire its first airborne data in 2021, with the full instrument package (imaging spectrometer, LiDAR, panchromatic camera) starting in 2022. It is expected to acquire data for the core

[42] This infrastructure was already listed in the 2015 Roadmap for Research Infrastructures (upgrade for the 2019 Roadmap for Research Infrastructures).

investigators (namely: University of Zurich, ETH Zurich, Eawag, Empa, EPFL, University of Lausanne, University of Fribourg, and the International Centre for Earth Simulation (ICES)), and expand to other investigators with interest in such data and products (including commercial use).

b. International level

ARES remains unique in its setting. Several international key infrastructures exist, using advanced imaging spectrometers as well as LiDAR instruments. Key infrastructures are the Carnegie Airborne Observatory (CAO), focusing on tropical forests and coral reefs, the Airborne Package of the National Ecological Observatory Network (NEON), covering the North American continent, and NASA instruments (G–LiHT Imager (NASA Goddard), AVIRIS–NG and ASO (NASA JPL)). All of these facilities have already been in existence for several years. ARES will cover primarily temperate, Mediterranean, taiga and tundra ecosystems, which until now have not been well assessed.

c. Development prospects

Observational approaches using air- and space-borne instruments feeding Earth System models have gained in importance over time. Airborne platforms increasingly contribute to testing and standardising retrievals for the Earth System before being implemented at larger scale in satellite instruments. In parallel, space agencies are developing space-based infrastructure to measure key contributions to the Earth System. The European Space Agency (ESA) as well as the European Union's Earth Observation Programme Copernicus are developing new satellite concepts (c.f. Copernicus Hyperspectral Imaging Mission for the Environment (CHIME)); NASA JPL is planning to build the Earth Surface Mineral Dust Source Investigation (EMIT) instrument, is currently flying the Global Ecosystem Dynamics Investigation LiDAR (GEDI) and is planning an hyperspectral imager to study surface biology and geology as a recommendation from the decadal survey of the National Academies of Science, Engineering and Medicine. In addition, regional, national and international efforts are underway to produce 'data cubes'– collections of relevant Earth System data, variables and processes, allowing us to monitor our accelerated changing environment. ARES is in a key position to contribute uniquely to the development of these new missions and data cubes, in particular providing access to environments previously not mapped in detail as well as an integrated system approach, ranging from measurements to data products and Earth System processes based on open access and FAIR schemes. ARES is an open platform and can be further expanded to include additional sensor payloads, such as imaging thermal spectrometers, synthetic aperture radar instruments, or fluorescence imagers.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution (2017-2024) UZH, UniL, UniFR: 5.96 m	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton tbd: 2.00 m
Swiss Confederation (2017-2024) ETHZ, Eawag, Empa, EPFL: 3.93 m	Swiss Confederation 0	Swiss Confederation tbd: 1.00 m
Third parties (2017-2024) Private foundations: 0.44 m	Third parties tbd: 9.22 m	Third parties tbd: 0.50 m
Total budget **10.33 m**	**Total** **9.22 m**	**Total** **3.50 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 7.37 m Operating costs 1.90 m Other costs 1.06 m	Investments 6.32 m Operating costs 1.65 m Other costs 1.25 m	Investments 0.65 m Operating costs 1.90 m Other costs 0.95 m
Total costs **10.33 m**	**Total** **9.22 m**	**Total** **3.50 m**

Development Phases	Years
Design	2017–2020
Preparation	2017–2021
Implementation	2019–2023
Operation	2021–2028

6. Center of Structural Electron Microscopy (COSEM)

Category: Instrument

Host institution(s): University of Zurich

Main funding sources: University of Zurich, Foundations

Description / Development prospects

a. National level

Overview

The importance of modern cryo-electron microscopy (cryo-EM) for molecular and cellular structural biology is founded on the recent revolution in the field, which was acknowledged by the award of *the 2017 Nobel Prize in Chemistry* to three pioneers of the technique. Cryo-EM has by now replaced X-ray crystallography as the premier method for determining the structure of challenging biological specimens, such as membrane proteins and macromolecular complexes, as reflected in numerous articles published in top journals in recent years. The breakthrough in molecular structural biology is now followed by a similar revolution in cell biology, which allows structure determination of macromolecular complexes *in situ*, thereby permitting the detailed structural analysis of tissues in health and disease. As a consequence of the described developments, the number of users and thus the demand for access to high-end cryo-electron microscopes has greatly increased and is expected to rise further in the future. We thus propose establishing the Center of Structural Electron Microscopy (COSEM) to provide access to a state-of-the-art cryo-EM infrastructure for researchers at the University of Zurich (UZH) and throughout Switzerland. COSEM builds on the already established high-end cryo-EM infrastructure at UZH and plans to update and extend it. The described project should thus be considered as major upgrade of an existing infrastructure. The facility will be managed by the Center of Microscopy and Image Analysis (ZMB) at UZH, which already runs the existing electron microscopes, and will be supervised by a scientific advisory committee. Whereas part of the funds requested for the project will be used to finance the running costs of the centre, a significant share will be contributed by user fees. The establishment of COSEM will meet the increasing demand for cryo-EM at UZH and nationwide and thus keep Switzerland internationally competitive in this rapidly growing field. The centre will be part of the decentralised services for cryo-EM and thus will be an attractive factor going forward. The long-term objective is a decentralised national centre for cryo-EM established by several national research institutions in which COSEM will participate.

Detailed description

COSEM will to a large extent rely on existing cryo-electron microscopes but will also attempt to acquire new infrastructure. In its final stage it is planned that the centre will run two 300 keV Titan Krios, a 200 keV Talos Arctica and a cryo-Focused Ion Beam (cryo-FIB). One 200 keV cryo-electron microscope (Titan Krios 1) is already in operation and funding of the second (Titan Krios 2) is secured: this will be up and running by 2020. Funding for the 200 keV Talos Arctica, the cryo-FIB (including a cryo-stage), the update of the two 300-keV microscopes (update of Krios 1 with a new detector and update of Krios 2 with a phase plate) and service contracts for the new detectors is currently still open. COSEM will be part of the ZMB, which will provide management and technical support and maintain the interface to the users. The ZMB is an open and advanced facility at UZH which provides access to various high-end imaging techniques in microscopy. The facility and instruments are open to research groups at UZH as well as to external institutions for a nominal fee covering project-related costs (e.g. training, operator-based imaging and quality assurance). All of this ensures a cost-effective and open access to state-of-the-art imaging technologies and expertise. The ZMB also contributes significantly to the training and education of scientists in imaging and microscopy. Internal and external users will be trained by the ZMB staff before being able to sign up for microscopy time. Training will be provided for sample preparation, the operation of microscopes and data analysis. Whereas a similar operation scheme is foreseen for COSEM, the use of delicate high-end cryo-electron microscopes will require more extensive training and a larger financial contribution to the running costs. To meet these aims and provide support for all instruments, the ZMB already employs experts in advanced electron microscopy techniques and an IT specialist. It is planned that they will be supported by another scientist dedicated to the operation of

COSEM, who will be recruited during the implementation phase and whose salary will be met from the requested budget. The scientist will be employed by the ZMB and will be responsible for the maintenance of the microscopes and the training of new users.

b. International level

COSEM is planned as a world-leading centre for structural biology and would therefore draw world-wide attention. The requested investment would allow us to establish and maintain a leading facility in the fields of structural and cell biology. The instruments will also be available to scientists abroad if the local community does not utilise the centre's capacity.

c. Development prospects

Despite the recent breakthroughs, cryo-EM remains a dynamic and rapidly developing field. Direct electron detectors were introduced only six years ago and are still under development. Similarly, sample preparation and image analysis are likely to be developed further in the coming 5 to 10 years. Whereas the structure determination of single particle analysis is now routine and accessible to a large user community, a similar development for cryo-electron tomography has yet to occur. A major aim of COSEM will therefore be to maintain its high-end standards and to drive new technological developments. To this end, the members of the ZMB including the employed staff scientist and the scientific advisory committee will routinely attend technical conferences and interact with the relevant companies. It is foreseen that next generation detectors, phase plates and image processing software will become available over the projected duration of the centre. COSEM and the ZMB are committed to following these developments and to maintaining the centre as a facility offering state-of-the-art services to researchers in Switzerland.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution UZH: 2.9 m	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF: 0.7 m Foundations: 1.0 m	Third parties User fees: 0.4 m tbd: 4.7 m	Third parties User fees: 0.4 m tbd: 0.8 m
Total budget **4.6 m**	**Total** **5.1 m**	**Total** **1.2 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 4.6 m Operating costs 0 Other costs 0	Investments 3.7 m Operating costs 1.4 m Other costs 0	Investments 0 Operating costs 1.2 m Other costs 0
Total costs **4.6 m**	**Total** **5.1 m**	**Total** **1.2 m**

Development Phases	Years
Design	2018–2020
Preparation	2019–2020
Implementation	2021–2024
Operation	2021–2028

7. Linguistic Research Infrastructure (LiRI)

Category: Information and services infrastructure

Host institution(s): University of Zurich

Main funding sources: University of Zurich

Description / Development prospects

a. National level

Overview

To shift linguistic research in Switzerland to a higher internationally competitive level, a number of bodies have successfully applied for a substantial upgrade of existing local linguistic infrastructure: two inter-departmental institutions at the Faculty of Arts and Social Sciences at UZH, namely the Zurich Competence Center for Linguistics (ZüKL) and the University Research Priority Program 'Language and Space' (URPP SpuR), some laboratories distributed over the campus and several institutes.

The new LiRI will, firstly, strengthen laboratory research in linguistics and neighbouring areas, which has become central in the era of digitalisation and big data in the study of language and speech, and will support data storage, data processing and analyses of the data with up-to-date datascience support in an unprecedented way. Secondly, this upgrade will allow pioneering new research combining naturalistic data with rigorous methods that so far could only be applied in the lab. This will bring Switzerland to the forefront of experimental and big-data-based linguistics research.

Detailed description

In addition to a bundle of new data acquisition/generation devices (mainly in phonetics, psycholinguistics and neurolinguistics with mobile and stationary eye-tracking devices, EEG systems, sound-proof-cabins, an anechoic chamber etc.), concentrated in one new linguistic laboratory unit, the core and linking base of the LiRI will be a LiRI Information System (LIS) whose main functions will be:

a. to channel the large volume of data produced not only by the LiRI Data acquisition components, but also by data coming from academic institutions from outside UZH (working with language data and linguistic databases) into standardised, interoperable and open-access resources (data management); detailed access rules for contributing and non-contributing partners will be set up as part of the LiRI rules of procedure as well as a set of minimal standards for the quality of hosted research data, digital assets and metadata; all tools and data hosted by LiRI will be subject to the FAIR principles of Open Access;
b. to support empirical research from data acquisition to publication (data science).

LiRI is conceived in its full form as a national platform for linguistic data storage/processing/science, uniting as many linguistic data resources of all kinds (text, audio, video, EEG etc.) as possible in one data centre. It brings together many linguistic research units from all over the country as well as academic institutions and cooperation partners such as the Swiss Academy of Humanities and Social Science (SAHS). LiRI will thus considerably strengthen national cooperations and boost inter-varsity dialogue and projects.

b. International level

LiRI will boost the visibility of linguistics at UZH, which integrates the largest linguistic research community of Switzerland (about 20 full professors, many third-party funded projects and huge local research and training initiatives). Existing international collaborations and the international Advisory Board will help to develop LiRI into one of very few large laboratory and data management units for linguistics (and related disciplines) in Europe. Additionally, LiRI is embedded in European infrastructure initiatives. UZH already collaborates with DARIAH, a pan-European infrastructure for arts and humanities scholars working with computational methods. UZH is interested in participating in CLARIN (initiative led and directed by *ZüKL*, the Zurich Competence Center for Linguistics; some of our leading experts are already members of CLARIN D). Membership in these two organisations would allow the research community to contribute to and benefit from the two most important European infrastructure networks. Through systematic metadata requirements they help to structure all future linguistic data,

including those coming from our external cooperation partners, and to make them accessible long-term thanks to widely used repositories.

c. Development prospects

LiRI will bring UZH and its national and international partners to the forefront of experimental and big-data-based linguistic research, taking into consideration also the European funding agencies' policy of sustainable research infrastructures in the present and future programme (Horizon Europe: https://ec.europa.eu/research/infrastructures). The new devices, synthetic lab structure and the new staff (data scientists/research methods consultants, technician, system administrator/coordinator) will make it possible to increase the number and size of third-party funded projects, both nationally and internationally (SNSF: NCCR funding scheme, ERC funding schemes, other European programmes), with scholars in academia and industry (e.g. hearing aids, brain-computer interfaces, neuromodulation, learning and training software). We expect a rapid growth of demand from 2020 onwards (when LiRI will start to be implemented), and aim to launch new research projects of considerable size such as NCCRs or ERC grants as well as by industry partners, who are already showing interest in the new laboratory devices and are granting seed money for pilot studies. The planned participation in CLARIN thanks to the repository facility integrated in LIS will both enhance new research initiatives and increase demand for support in data storage, data management and data science provided by LiRI.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution UZH: 2.15 m	Higher Education Institution UZH: 5.07 m	Higher Education Institution UZH: 3.6 m
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF: 0.55 m User fees: 0.05 m tbd: 0.15 m	Third parties SNSF: 0.95 m User fees: 0.66 m tbd: 0.12 m	Third parties User fees: 1.12 m tbd: 0.08 m
Total budget **2.90 m**	**Total** **6.80 m**	**Total** **4.80 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 1.61 m	Investments 2.06 m	Investments 0
Operating costs 1.14 m	Operating costs 4.62 m	Operating costs 4.72 m
Other costs 0.15 m	Other costs 0.12 m	Other costs 0.08 m
Total costs **2.90 m**	**Total** **6.80 m**	**Total** **4.80 m**

Development Phases	Years
Design	2017–2018
Preparation	2018–2019
Implementation	2020–2022
Operation	2023–2037

Annex A2: Update of national infrastructures from the 2015 Roadmap

Foreword

The research infrastructures recommended for implementation in the 2015 Roadmap were the object of an implementation update between the end of 2018 and the beginning of 2019. The data collected from the infrastructure management is presented in Annex A2. The RIs are listed by discipline:

- Humanities and Social Sciences
  - Swiss Art Research Infrastructure (SARI)
  - Data and Service Center for the Humanities (DaSCH), formerly Swiss Digital Humanities Center (SDHC)
  - Mixed-Reality Lab for Behavioral Research (MIRAL)

- STEM
  - Swiss National Ion-Microbe Platform (SwissNIP)
  - Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials (DynaMatLab)
  - Next Evolution in Sustainable Building Technologies (NEST)
  - The future of dark matter detection with liquid xenon XENONnT and DARWIN
  - ATHOS beamline at the Swiss X-ray Free Electron Laser SwissFEL
  - Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI)
  - Center for Biomedical Research in Space
  - Swiss Plasma Center (SPC)

- Life Sciences
  - National Research Centre for Animal Cognition
  - Swiss Research Network of Clinical Pediatric Hubs (SwissPedNet) (including the Center for Pediatric Systems Pharmacology and Technology, SwissPedPha)
  - Swiss Center for Musculoskeletal Biobanking and Imaging and Clinical Movement Analysis (Balgrist campus)
  - Neuchâtel Platform for Analytical Chemistry (NPAC)
  - Information and computational service infrastructure network to support biomedical research in Switzerland (BioMedIT)

- E-infrastructures
  - The Swiss edu-ID and the Swiss Academic Cloud based on the Academic Network SWITCHlan
  - Swiss Data Science Center (SDSC)

It should be noted that those infrastructures in the 2015 Roadmap which have undergone a major upgrade for the 2019 Roadmap only feature in Annex A1. These are the High-Performance Computing and Networking (HPCN-24), Swiss Light Source SLS 2.0, Airborne Research Facility for the Earth System (ARES) and the Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR).

Some of the RIs described here do not meet the new criterion in the 2019 Roadmap, namely the requirement to have a minimum budget of CHF 5 million, as figures here are updates of data in the 2015 Roadmap. The RIs in the 2015 Roadmap had to meet the following criteria:

- *to make a major contribution to the development of an area of knowledge or research (scientific added value);*
- *to be used intensively by researchers in Switzerland (national importance);*
- *to be accessible to national and international research communities (open access);*
- *to be situated in a single location or organised within a network of sites with a centralised management structure.*

NB:

1) **The financial information given below reflects the planning figures provided by the higher education institutions/infrastructure management.**
2) **The financial figures in this document for the ERI periods 2021–2024 and 2025–2028 are forecasts and are only given as a rough estimate of probable future costs and how they will be allocated.**
3) **Last information update: October 2018–February 2019**

Swiss Art Research Infrastructure (SARI)

Category: Information and Service Infrastructures

Host institution(s): University of Zurich

Main funding sources: University of Zurich, ETH Zurich, external Foundations

Description / Development prospects

a. National level

Overview

The Swiss Art Research Infrastructure (SARI) provides access to advanced digital research tools and domain-specific research environments combined with unified and mutual access to research and collection data, digitised visual/textual resources, and related reference data in the field of art history, architecture and urban planning, archaeology, history studies, religious studies, and related disciplines. By providing universal access to both pivotal, new digital research technologies and digital resources through its modular, tailor-made research environment and state-of-the-art technological framework, SARI enhances the accessibility, interoperability re-usability, and long-term sustainability of future research and collection data in art history and related disciplines according to FAIR principles. Thus, SARI combines and leverages the unique scholarly expertise and visibility of specialised research institutions in Switzerland and enables new and advanced approaches in future digital research.

Detailed description

SARI develops and maintains a technological framework for unified access to domain-specific research resources, advanced research tools, and tailor-made research environments entirely based on internationally acknowledged, sustainable, and yet extendable standards for data modelling and data exchange in the semantic web. This includes the Resources Description Framework (RDF) and Linked Open Data technology (LOD) for semantic data and semantic web technology, the International Image Interoperability Framework (IIIF) for access to digital assets, and the Conceptual Reference Model of the International Council of Museums (CIDOC-CRM) for data modelling and harmonisation specific to the field art history (among others). Thus, SARIs comprehensive technology stack operates entirely open source-based, and its underlying standards for data modelling are fully aligned with standards and principles recommended by the W3C, assuring long-term findability, accessibility, interoperability, and re-usability of research data in the semantic web. As an outcome, research and collection data made available through SARIs technological framework are accessible as part of a global knowledge graph (both machine-readable and human-interpretable) and, thus, are available for both further research methods and sustainable long-term achievability according to the FAIR principles, as requested by most national and international funding agencies. This results in an unprecedented framework for sustained, unified, mutual, and mainly open access to research and collection data, first-hand digital visual resources, and scholarly acknowledged reference data from numerous specialised research institutions, academic research projects, museums, archives, and collections. SARIs framework thus overcomes not only the institutional and technical fragmentation in the field of art history, but also national language barriers by giving access to scholarly established, yet extendable multilingual vocabularies, As such, SARI becomes a role model for further, international institutional and academic cooperations.

With the primary operative partners University of Zurich, ETH Zurich, and the SIK-ISEA, Switzerland's leading institutions in the field of digital art history are substantially contributing technology and pivotal data to SARI. Thanks to the collaboration with all major national and international institutions in the field, SARI fosters a cost-effective use of existing resources and the tools and research and teaching across disciplines (see below for international partners).

b. International level

In order to guarantee maximum leverage, SARI is developing its research environment and research tools in close cooperation with international partners, such as the British Museums 'ResearchSpace' project (long-term funded by the Andrew W. Mellon Foundation) and uses the same technology stack as major cultural institutions worldwide (The Getty Research Institute and Museums, Yale Center for British Art, British Museum, etc.) to mutually provide access to research resources, thus resulting in the availability of millions of digital assets and large numbers of datasets worldwide through the same, unified technology stack

implemented by SARI. Pivotal extensions to semantic ontologies related to CIDOC-CRM are currently being developed in cooperation with the CIDOC-CRM special interest group, the FORTH-ICS (Foundation for Research and Technology, Hellas/Heraklion), while upcoming ontological standards such as 'linked.art' are actively developed with the J. Paul Getty Trust, Los Angeles. Where needed, multilingual, domain-specific reference vocabularies are being developed in cooperation with major national and international players (libraries, research institutions, etc.) to ensure maximum acceptance both institutionally and within the international scientific community (GND, ULAN, AAT, others). As a result, SARIs semantic technology, research environment and tools are currently being adopted and further developed by leading institutions in the field. This includes the Harvard Centre for Renaissance Studies 'Villa I Tatti', Florence, the Bibliotheca Hertziana/MPG, Rome, and the Institute for the History of Science, MPG/Berlin (as part of the International Consortium for Open Research Data in the Humanities, CORDH, founded in 2018).

c. Development prospects

Based on the increasing availability of domain-specific datasets and a rapidly growing interest in digital research technology and methods in art history and related disciplines, we identify a dramatically growing demand for advanced digital research technology, research tools and universal access to digital research resources from specialised institutions, as provided by SARI. Requirements from national and international funding agencies to provide findable, accessible, interoperable, and re-usable research data (FAIR) accelerate this demand. As a result, SARI is activily collaborating in numerous research project proposals to SNSF, ERC and alike, to pursue its mission to provide advanced digital research tools in domain-specific research environments. To avoid redundancies on a national level, SARI is closely collaborating with the Data and Service Center for the Humanities (DaSCH). In this, SARI is defining standards for data modelling and data exchange specific to the field of art history, that align with DaSCH's data ontology and infrastructure for long-term accessibility allowing for a smooth transition of research data produced on within SARI into DaSCH's longterm storage (KNORA). Likewise, SARI implements DaSCH's technological framework (IIIF-Sever "Sipi"), making DaSCH the preferred service provider for research data produced in SARI (for international development perspectives, see above).

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton University of Zurich: 3.04 m	Canton 0	Canton 0
Swiss Confederation ETH Zurich: 0.66 m	Swiss Confederation ETH Zurich: 0.42 m (projection)	Swiss Confederation ETH Zurich: 0.42 m (projection)
Third parties Ext. Foundation: 0.80 m	Third parties SNSF: 0.65 m (projection) Zurich Research Center, MPG: 2.00 m Foundations: 0.40 m (projection)	Third parties SNSF: 0.65 m (projection) Foundations: 0.40 m (projection)
Total budget **4.5 m**	**Total** **3.47 m**	**Total** **1.47 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0.56 m Operating costs 2.86 m Other costs 1.08 m	Investments 0.5 m (max projection) Operating costs 0.97 m (max projection) Other costs 2 m (projection, MPG)	Investments 0.5 m (max projection) Operating costs 0.97 m (max projection) Other costs 0
Total costs **4.5 m**	**Total** **3.47 m**	**Total** **1.47 m**

Development Phases	Years
Design	(2014–) 2017
Preparation	2017
Implementation	2018–2019
Operation	2019–beyond

Data and Service Center for the Humanities (DaSCH)

Category: Information and service infrastructures

Host institution(s): Digital Humanities Lab, University of Basel on behalf of the Universities of Basel, Bern and Lausanne

Main funding sources: Swiss Academy of Humanities and Social Sciences (SAHSS), universities

Description / Development prospects

a. National level

Overview

The Data and Service Center for the Humanities (DaSCH) (previously called the Swiss Digital Humanities Center, SDHC) provides data curation, long-term access, persistent identifiers (for data records, based on the "Archival Resource Key", ARK), and research and analysis tools for qualitative research data in the humanities. Qualitative data are defined as complex, interwoven data and connected digital objects (e.g. databases with or without linked digital objects such as images, facsimiles, movies). DaSCH guarantees the long-term accessibility of research data in the humanities and the adherence to open standards while propagating the use of advanced digital methods and technologies in a way that the persistence of data and tools to work with scientific data from the humanities can be achieved. It provides FAIR access to the data and supports all relevant standards for interoperability.

Detailed description

DaSCH develops and maintains a software platform consisting of a database based on Linked Open Data technologies (LOD) and the "Resource Description Framework" (RDF), a middle ware (Knora) which implements a full timestamp-based versioning (version history) on field level, permission control and an application programmers interface (API) that is compliant with the open REST-standard ("Representational State Transfer"). The flexible data modelling with LOD allows DaSCH to use *one single* infrastructure for data, metadata, models and structures from any project irrespective of the data concept used. The architecture of Knora goes well beyond the "Open Archival Information System" (OAIS) reference model for digital archives, where OAIS only *emulates* the processes of an analog archive containing physical artifacts in the digital domain. For *qualitative* research data this model is not sufficient: the data themselves and not only their descriptive metadata need to be searchable at any time, data have to be annotatable and linkable on a very fine-grained level. In addition, the data objects need to be changeable, e.g. if new findings emerge, while previous versions are preserved. The field-level-based version history of Knora enables these features and therefore the term "*keep-alive*" archive is used. Citations using permanent identifiers based on ARK (provided by DaSCH) always show a data object as it was at the moment the ARK identifier was created. An important aspect of qualitative data in the humanities is that, in most cases, the preservation of such datasets alone makes little sense. The way the *datasets* are accessed and *re-used*, queries and views etc. often form an integral part of the knowledge represented by the datasets. Thus, the infrastructure of DaSCH provides components to *emulate* queries and user interfaces using modern responsive web technologies.

DaSCH implements, encourages or enforces the use of well adapted and accepted standards. The REST API is based on "JavaScript Object Notation – Linked Data" (JSON-LD), a widely accepted standard for linked open data. For images, DaSCH exclusively uses the International Image Interoperability Framework (IIIF), and texts can be imported/exported as standard TEI/XML (Text Encoding Inititaive). DaSCH consequently guarantees a high degree of interoperability for research data. DaSCH also fully complies with the FAIR data principles as required by most funding agencies. However, fine-grained access control is possible if required (e.g. copyright issues, data protection law etc.).

b. International level

International comparison shows that there is no single repository that can meet everyone's needs. There are various approaches ensuring long-term access to research data. The solution DaSCH provides is very well positioned in an international comparison. DaSCH uses an adequate, very advanced and innovative technology that is very promising for the future and shows great potential. It is open to

international cooperation by using accepted standards (IIIF, LOD, RDF, REST, JSON-LD etc.) and close collaborations and exchanges with similar national and international institutions have been established.

c. Development prospects

Since research in the humanities shows an ever-increasing dependence on digital data, tools and methods, the demand for the services of DaSCH is expected to grow dramatically in the future. In addition almost all Swiss universities are establishing Digital Humanities departments, which will further increase the need for long-term storage of curated qualitative data in the humanities. It is planned that DaSCH will be in charge of the institutionalisation of the New Infrastructure for Editions (NIE-INE, swissuniversities P5 project), which will further increase the volume of DaSCH. In the interest of avoiding redundancy, DaSCH closely cooperates with both with the Swiss Art Research Infrastructure (SARI) and the Swiss Center for Expertise in Social Sciences (FORS) both on an institutional and technical level. DaSCH adopts the standards of SARI in the domain of Arts and Architecture, secures long-term accessibility and provides interoperability tools (e.g. IIIF-Server SIPI) for SARI. Common standards for software platforms (LOD, RDF, ontologies, angular framework etc.) allow efficient knowledge-sharing with SARI and FORS. Common portals and data gateways are planned in order to offer single-stop services for research projects that cross domain boundaries.

Remark on d) Costs: The budget figures for the period 2021–2024 are target figures.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 1,545,000	Canton 4,080,000	Canton tbd
Swiss Confederation 2,000,000	Swiss Confederation 6,870,000	Swiss Confederation tbd
Third parties 200,000	Third parties 400,000	Third parties tbd
Total budget 3,745,000	**Total 11,350,000**	**Total tbd**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 1,356,171	Investments 4,110,156	Investments tbd
Operating costs 2,264,582	Operating costs 6,863,286	Operating costs tbd
Other costs 124,247	Other costs 376,557	Other costs tbd
Total costs 3,745,000	**Total 11,350,000**	**Total tbd**

Development Phases	Years
Design	2010–2012
Preparation	2013–2015
Implementation	2016
Operation	2017–

Mixed-Reality Lab for Behavioral Research (MIRAL)

Category: (Instruments, Information and service infrastructures, Technical infrastructures) Instruments (Category a)

Host institution(s): University of St Gallen

Main funding sources: University of St Gallen

Description / Development prospects

a. National level

Overview

With the Mixed Reality Lab for Behavioral Research (MIRAL), the University of St Gallen has established a research infrastructure (RI) with the long-term objective of developing an internationally renowned mixed-reality lab for research on behaviour of students, consumers, managers, and employees in both physical and computer-enhanced environments.

Detailed description

With its combination of biometrical measurement capabilities, VR facilities, multi-user decision-making lab environment and extensive student panel, MIRAL is currently of key interest to behavioural researchers at the University of St Gallen. MIRAL also welcomes researchers from other Swiss and international research institutions (particularly behavioural consumer and management researchers but also behavioural finance and behavioural economics researchers).

The RI not only allow researchers of the host institution to use a state-of-the-art laboratory to conduct their behavioural research, it is also considerably increasing its action scope. To scientists in Switzerland and beyond, MIRAL is a unique research environment which will further improve the reputation of the university and of research in Switzerland. MIRAL also strengthens the excellent status of Switzerland in the research community by providing a one-of-a-kind lab infrastructure to research problems of the next decade in the computer-aided environments between the physical and virtual world.

b. International level

The behavioural researchers at the University of St Gallen collaborate extensively with other Swiss, European, and North American schools, which greatly benefit from the RI and strengthen the academic position of Swiss behavioural research across different disciplines both nationally and internationally.

c. Development prospects

MIRAL is being established in two stages. In the first stage (2014–2017), the University of St Gallen invested monetary and intellectual resources to establish a state-of-the-art behavioural lab. This lab now includes common laboratory infrastructure to address research questions in the real, physical and the virtual, online world (e.g., infrastructure, PCs, shopping aisle). In the second stage (2018–2021), MIRAL will be improving integration of VR environments and biometrical measurement, extending its biometrical measurement capabilities (EEG, ECG) and developing lab team's capabilities for enhanced support in terms of scientific rigour of experiments.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 1.952 m	Higher Education Institution 1.45 m	Higher Education Institution 1.55 m
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 0.612 m	Third parties 0	Third parties 0
Total budget 2.564 m	**Total 1.45 m**	**Total 1.55 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments N/A	Investments 0.35 m	Investments 0.450 m
Operating costs N/A	Operating costs 0.95 m	Operating costs 0.950 m
Other costs N/A	Other costs 0.15 m	Other costs 0.150 m
Total costs 2.564 m	**Total 1.45 m**	**Total 1.55 m**

Development Phases	Years
Design	2014–2015
Preparation	2015
Implementation	2015–2018
Operation	2018–

Swiss National Ion-microbe Platform (SwissNIP)

Category: Technical Infrastructure

Host institution(s): University of Lausanne

Main funding sources: University of Lausanne / SNF

Description / Development prospects

a. National level

Overview

The SwissNIP platform hosts analytical facilities for high spatial resolution chemical and isotopic surface analyses in Earth sciences, with applications to materials and life sciences. It includes cutting-edge analytical instruments currently federated under the Center of Advanced Surface analysis (operated by the University of Lausanne and the EPFL) and the SwissSIMS, which is owned by the University of Lausanne, Bern, Geneva and the ETHZ. All these instruments are located at the University of Lausanne, in the Geopolis building.

Detailed description

The SwissNIP facility is being upgraded with two newly developed RF-Hyperion sources for high spatial resolution analysis of positive ions and their isotopes. This will further enhance the capability to perform quantified, high-resolution isotopic and elemental analyses without loss of analytical precision. The new RF-sources will allow us to analyse metals (i.e. electro-positive elements and isotopes) with high precision and a spatial resolution of approx. 50 nanometre on the NanoSIMS, and about 1 micrometre on the SwissSIMS. This ion microprobe platform is unique in Switzerland (indeed in Europe) and gives Swiss scientists a unique advantage. Furthermore, UNIL has acquired and installed a Field Emission Gun (FEG) electron microprobe that provides high resolution major and minor element analytics to a scale of approx. 100 nm. It is the perfect electron-beam instrument in combination with the upgraded ion microprobes. The FEG instrument will be made available (for max. 25% of the time) for projects linked to the SwissNIP project. In addition, the (first ever!) CryoNanoSIMS became fully operational in the autumn of 2015, permitting samples to be prepared and analysed for chemical and isotopic composition at ultra-high spatial resolution without any loss of soluble compounds from the cells under study. This capability is now boosted by a joint acquisition between UNIL and EPFL of a state-of-the-art Gemini 500 CryoSEM instrument, also installed in Geopolis.

Access to the facility is open to Swiss and international researchers, granted on the basis of project proposals submitted to the SwissSIMS scientific steering committee, which is composed of members of the Swiss and international scientific community. Since the platform does not have any proper federal funding, individual users are required to pay for their analysis time. While the SwissSIMS is run entirely as a national facility, the NanoSIMS, the LA-ICPMS and the FEG_EMPA are made available to the Swiss research community 25% of the time. The budget was calculated at the percentage.

b. International level

Today, the combination of cutting-edge large-radius ion microprobe SwissSIMS and NanoSIMS under one roof exists in only two other research institutions in the world. With the proposed upgrade to new and much more powerful ion sources and the development of the CryoNanoSIMS, plus the availability of a FEG electron microprobe for ultra-high spatial resolution major element analysis, and a CryoSEM instrument, the SwissNIP platform offers Swiss researchers an absolutely state-of-the-art analytical facility.

c. Development prospects

The facility will be maintained and upgraded to stay at the forefront of analytical capacities. The main limiting factors at this point are financial and personnel limitations. We are striving to obtain financing for an additional technical position to guarantee the 24/7 operation of the facility. At this point, new developments are under way especially in the area of NanoSIMS technology, in particular with regard

to ion source technology and new, stable electronics, which will permit extremely high analytical precision stable isotope analysis with ultra-high spatial resolution. This represents a big step forward in analytical capability. At this point, we project an investment of CHF 4.5 m for these new developments, and will attempt to raise the funding required. Depending on advances made on the quantitative side of the TofSIMS analytics, we might consider entering this domain at a future time.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 3,840,000	Higher Education Institution 4,250,000	Higher Education Institution 3,050,000
Canton 0	Canton 0	Canton 0
Swiss Confederation ETH domain: 1,430,000	Swiss Confederation ETH domain: 2,450,000	Swiss Confederation ETH domain: 1,200,00
Third parties SNSF:410,000; EU: 70,000	Third parties SNSF: 1,000,000; tbd: 500,000	Third parties SNSF: 500,000
Total budget 5,750,000	**Total 8,200,000**	**Total 4,750,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 2,170,000	Investments 4,500,000	Investments 1,000,000
Operating costs 3,580,000	Operating costs 3,700,000	Operating costs 3,750,000
Other costs 0	Other costs 0	Other costs 0
Total costs 5,750,000	**Total 8,200,000**	**Total 4,750,000**

Development Phases	Years
Design	2011
Preparation	2011–2012
Implementation	2013–2018
Operation	2017–2030

Swiss Laboratory for the Advanced Studies on the Dynamic Behaviour of Materials (Dy-naMatLab)

Category: Instruments

Host institution(s): SUPSI

Main funding sources: SUPSI, Competitive Funds

Description / Development prospects

a. National level

Overview

The Swiss Laboratory for the Advanced Studies on the Dynamic Behaviour of Materials is a centre specialised in the mechanical characterisation of materials in dynamics able to measure accurately the stress-strain curves of materials in tension, compression and shear at a large range of strain-rates (from 10^{-6} a 10^{5} s^{-1}) and temperatures.

The Laboratory acts as a point of reference for industry and research centres (at regional, national and international level) as key-player support in the design, development and optimisation of production processes.

The Laboratory develops research on materials and structures subject to dynamic-impulsive loads, favours the technological transfer and diffuses an integrated approach facing to design-testing to improve safety and quality of products.

Detailed description

In the laboratory is possible to perform tests in tension, compression, shear, torsion and bending for different materials at high strain-rates and over a large temperature range (77–1,500 °K). For example:

- Thin sheet steel used by the automotive industry.
- Steel used for the structures of nuclear reactors or defence.
- Plain and fibre-reinforced concrete.
- Aluminium and magnesium alloys used in aero-space.
- Fibre-reinforced composite polymers.

The laboratory's core facilities are based on the Modified Hopkinson Bars apparatus. Several set-ups are used to study the uni-, bi- and tri-axial behaviour of the materials in a wide range of strain-rate tests ($1 \div 10^{5}$ s^{-1}). The length of the apparatus ranges from some meters to 15 metres, and there are different bar diameters, needed to test for example:

- Metals (diameter 10 and 12 mm).
- Polymers (diameter 20 mm).
- Concretes and rocks (diameter 60 mm).

Additional facilities are present to test materials in intermediate strain rate regime (0.1-100 s^{-1}) and in quasi- static regime. Systems of transient recorder (50 Msample/s) and measurement chains (displacement transducers, fast camera, etc.) make it possible to register all data.

b. International level

The Swiss Laboratory for Advanced Studies on the dynamic behaviour of materials continues in the same way pursued by the existing DynaMat Laboratory. The research infrastructure will enhance the role as reference point for industries and research centre as well as international universities. The development of training and mentoring of Swiss and international young researchers will create the opportunity to do cutting-edge studies and collaborate with other world-class facilities and experts. The Laboratory will act as a node in the global network of leading research institutions involved in the dynamic behaviour of materials, providing a supportive environment for Swiss industry. This infrastructure is part of the International Network of Laboratories of dynamic of materials (DYMAT).

c. Development prospects

Dynamic behaviour of materials is an ever expanding area of broad interest to the scientific community and industry. Understanding the dynamic response of materials improves the design and safety of products and structures by means of calibration and validation of numerical models.

The Swiss Laboratory for Advanced Studies on the dynamic behaviour of materials is strongly specialised in experimental issues, analysing the material behaviour in mono-axial, bi-axial and tri-axial loading conditions in combination with additional variables such as temperature and other severe conditions (i.e. irradiation).

In order to become a reference laboratory in the above-mentioned areas, it is necessary to constantly improve the set of devices by designing new machines and constructing complementary set-ups. New machines are essential in order to respond to the needs of research and development in the field of dynamic behaviour of materials. In order to cover a wide area of applications it is necessary to study torsion behaviour as well as the combination of tension/torsion. Traditional Split Hopkinson Pressure Bar (SHPB) can easily respond to the dynamic indentation purposes (two set-ups have been scheduled). Many industrial applications involve biaxial stress conditions, and so dynamic biaxial behaviour studies are required. The new RI must respond to these issues by developing biaxial apparatus at medium and high strain rate (biaxial MHB). Moreover, the new TriHB must be completed and collision test apparatus built. Finally, the system of MHB in bending is required to study the fracture mechanics parameters in a wide range of strain rates.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 2,090,370	Higher Education Institution 2,723,700	Higher Education Institution 2,167,900
Canton 895,873	Canton 1,167,300	Canton 929,100
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 970,000	Third parties 1,000,000	Third parties 1,200,000
Total budget 3,956,243	**Total 4,891,000**	**Total 4,297,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 797,000	Investments 594,000	Investments 0
Operating costs 2,460,000	Operating costs 3,460,000	Operating costs 3,460,000
Other costs 699,243	Other costs 837,000	Other costs 837,000
Total costs 3,956,243	**Total 4,891,000**	**Total 4,297,000**

Development Phases	Years
Design	2017–2020
Preparation	2020–2022
Implementation	2022–2026
Operation	2026–2028

Next Evolution in Sustainable Building Technologies (NEST)

Category: Technical Infrastructure

Host institution(s): Empa, Eawag

Main funding sources: ETH Domain, Canton of Zurich, SFOE, SERI, Ernst Göhner Stiftung, Swisslife/ZKB, and numerous industrial partners

Description / Development prospects

a. National level

Overview

Since its inauguration in May 2016 and with the first two units operational, NEST has become a lighthouse for innovation in the building sector. A vast number of research groups from the ETH Domain and the universities of applied sciences together with their industrial partners (presently more than 130) are using NEST in order to explore the viability of new materials, systems and concepts. The unique flexibility of NEST combined with the inclusion of real users in all experiments has proven to be a true catalyst for innovation. First products and concepts which have been initially developed within NEST projects are already on the market and many more are in the pipeline. Furthermore, NEST has a broad coverage in national and international media, repeatedly wins awards and since opening has been visited by roughly 1,000 persons per month.

Detailed description

The development of the NEST concept started in 2009. By the end of 2013 the consortia for the first units were formed and finances for the construction of the backbone were assured. The actual construction started in 2014 and the official inauguration of NEST took place in May 2016 with the two units meet2create (Lucerne University of Applied Sciences and Arts) and Vision Wood (Empa & ETH Zurich) then ready. The energy hub (Empa) and water hub (Eawag) became operational later the same year.

Since then, three more units have been completed: Solar Fitness&Wellness (Empa), Urban Mining and Recycling (KIT and University of Stuttgart) and SolAce (EPFL). The dfab house (NCCR Digital Fabrication) was opened in February 2019. HiLo (ETH Zurich) will be constructed in 2019 and two to three more units are presently in an early stage. A total of more than 80 peer reviewed papers have been published in combination with the units.

NEST is definitely contributing to the acceleration of innovation in the building sector. The gap between academia and industry can be narrowed thanks to the collaboration between all stakeholders within a NEST project. However, it is important to further develop instruments and tools to facilitate the transfer of know-how and to accelerate the learning rate of all players involved.

b. International level

NEST is also gaining international recognition in the Living Lab scene thanks to the unique features it offers. To the best of our knowledge, there exists no comparable platform with a similar approach which is research- rather than user-dominated. The number of international delegations from the public sector and from industry is increasing. Numerous large international companies have recently joined NEST as partners or are planning to do so in the near future. Collaborations have been established with high-ranked institutions such as Harvard University or Imperial College.

The highlight on the international level, however, was the creation of the living unit Urban Mining and Recycling under the leadership of University of Stuttgart and Karlsruhe Institute of Technology. The unit was opened in early 2018 and is a true break-through in terms of circular economy in the construction sector.

c. Development prospects

It can be expected that within 2-3 years the available space for units will be used up and then the first-generation units will be replaced. The topic of the units is not defined yet, it is planned to keep the open innovation approach and to react flexibly to the interest of potential partners. However, efficient use of

resources (materials, energy, water) will remain a core topic together with comfort and usability. The potential of digitalisation in all these aspects will be further investigated. Besides digital planning and construction, topics such as the role of robots during the use phase will be of special interest. This includes the use of drones for inspection and repair or letting robots be part of the operation of a bistro. Again, user acceptance of such new concepts will be one of the central parts of research. While in the first years the focus was very much on the development of new units, more weight will be given in the coming years to the research carried out during operation of the units. This research should help to increase the market readiness of solutions developed within NEST. Other goals for the next years are one more unit with a strong international partnership and the development of new tools and instruments for technology transfer to the building sector.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton Canton of Zurich 3.5 m	Canton Canton of Zurich: 1 m	Canton Canton of Zurich: 1 m
Swiss Confederation ETH Board: 4 m Empa: 3 m Eawag: 0.2 m ETH Zurich: 2 m SFOE: 1 m	Swiss Confederation ETH Board: 4 m Empa: 4 m Eawag: 1 m SFOE: 1 m	Swiss Confederation ETH Board: 4 m Empa: 4 m Eawag: 1 m SFOE: 1 m
Third parties Industry: 9 m	Third parties Private foundations: 2 m Industry: 7 m	Third parties Private foundations: 2 m Industry: 7 m
Total budget **22.7 m**	**Total** **20 m**	**Total** **20 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 19.5 m Operating costs 3.2 m Other costs 0	Investments 10 m Operating costs 8 m Other costs 2 m	Investments 10 m Operating costs 8 m Other costs 2 m
Total costs **22.7 m**	**Total** **20 m**	**Total** **20 m**

Development Phases	Years
Design	2009–2013
Preparation	2013–2014
Implementation	2014–2016
Operation	2016–2030

The future of dark matter detection with liquid xenon XENONnT and DARWIN

Category: STEM

Host institution(s): University of Zurich

Main funding sources: SNF, ERC and international partners

Description / Development prospects

a. National level

Overview

DARk matter WImp search with Noble liquids (DARWIN) will be a new observatory in astroparticle physics, with the aim to identify the nature of dark matter, to reveal the nature of neutrinos (via the search for the neutrinoless double beta decay of ^{136}Xe), to observe solar neutrinos via elastic neutrino-electron and coherent neutrino-nucleus scatters, as well as solar axions and axion-like particles. It will employ a time projection chamber (TPC) filled with liquid xenon (50 tonnes in total, 40 tonnes inside the TPC), viewed by arrays of VUV-sensitive photosensors to detect both light and charge signals after a particle interacts with the xenon target. The TPC and its cryostat will be surrounded by a 15 m water Cherenkov shield, to veto interactions of cosmic muons and their secondary particles. The most likely location of the observatory will be at the Gran Sasso Underground Laboratory (LNGS) in Italy, the location of the current XENON1T and XENONnT experiments. The direct dark matter search via collisions of dark matter particles with atomic nuclei is highly complementary to indirect searches with AMS, CTA and IceCube and with direct dark matter production at the LHC, and many of the science channels complement independent experimental efforts in these areas by providing new information.

Detailed description

DARWIN, which was founded and is currently lead by Swiss groups, is the successor to the very successful XENON programme, with leading contributions from the UZH group. The XENON1T experiment, based on a xenon TPC with 3.2 tonnes of liquid xenon in total, has set the world's best constraints on the interactions of dark matter particles with nucleons for particle masses above 6 GeV. XENONnT, using 8 tonnes of liquid xenon, is in the construction phase and is expected to take first science data in late 2019. UZH is strongly involved in the design and construction of the inner detector, the TPC, in the characterisation in liquid xenon and cryogenic read-out of the photosensors, as well as in material screening with a high-purity germanium facility. DARWIN is in R&D and design phase, supported by two ERC grants (advanced grant at UZH, and consolidator at the University of Freiburg in Germany). As part of the ERC project, the UZH group is focusing on the optimisation of the TPC, namely its light and charge readout. It will build a vertical TPC prototype, to demonstrate electron drift over 2.6 m (the final size of the DARWIN TPC), and is investigating new, solid-state photosensors (SiPMs) which are excellent candidates to replace existing photomultiplier tubes (PMTs).The goal is to build a first TPC prototype with 4-pi light readout, which would make it possible to reduce the energy threshold of the observatory and thus increase its sensitivity to low-mass dark matter particles.

b. International level

The DARWIN observatory will be built and operated by an international consortium which currently is composed of 28 groups from Europe, Asia and USA. It is expected that additional groups will join in the next couple of years. This next-generation dark matter and neutrino project is on the new roadmap of the Astroparticle Physics European Consortium (APPEC), which has recently published its strategy for the years 2017–2026, as well as on several national roadmaps (e.g. Germany and Netherlands). With an expected exposure of 200 ton x years, DARWIN will probe cross sections of dark matter particles down to 2 x 10^{-49} cm^2, two orders of magnitude below the sensitivity of XENON1T, and will thus reach the so-called neutrino floor, where nuclear recoil signals from atmospheric neutrinos will constitute an irreducible background. It will probe dark matter particle masses up to several TeV, and will thus be highly complementary to the high-luminosity LHC. The observatory will also be able to measure for the first time the solar pp-neutrino flux with precision at or below the 1% level, thus testing solar models, and will be competitive in the search for the neutrinoless double beta decay process. Its discovery would have far-reaching implications, proving that neutrinos are their own antiparticles.

c. Development prospects

The goal of the present Memorandum of Understanding (MoU) of the DARWIN collaboration, signed by all the groups in late 2017, is to coordinate the R&D work which will serve as the basis for the Conceptual Design Report, to be submitted 2020/21. It will be followed by engineering studies and a Technical Design Report, expected for 2022/23. The construction phase will last from 2023–2024, with the commissioning and the start of science data-taking planned for 2025 and 2026, respectively. It is planned that the observatory will take data for at least ten years.

d. Costs (in CHF)

The costs in the Costs overview part refer to the total estimated costs of the project, including Swiss and international contributions. The third parties in the Swiss budget refers to the UZH ERC, as well as to the ERC grant at Freiburg University, and to other funds from our international partners. The total cost will depend on the xenon gas price, which can fluctuate.

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF (FLARE) 2 m EU (ERC UZH): 2.2 m (EUR 1.15) EU (ERC Freiburg): 2.3 m (EUR 1.15) International partners: 25.0 m	Third parties SNSF (FLARE) 5 m EU (ERC UZH): 1.6 m (EUR 1.15) EU (ERC Freiburg): 0.6 m (EUR 1.15) International partners: 44.3 m	Third parties SNSF (FLARE) 1.2 m International partners: 12.3 m
Total budget **31.5 m**	**Total** **51.5 m**	**Total** **13.5 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 30 m Operating costs 1.5 m Other costs 0	Investments 50 m Operating costs 1.5 m Other costs 0	Investments 12 m Operating costs 1.5 m Other costs 9
Total costs **31.5 m**	**Total** **51.5 m**	**Total** **13.5 m**

Development Phases	Years
Design	2017–2022
Preparation	2023–2024
Implementation	2025–2026
Operation	2026–2036

ATHOS beamline at the Swiss X-ray Free Electron Laser SwissFEL

Category: Instruments

Host institution(s): Paul Scherrer Institute (PSI)

Main funding sources: ETH Domain

Description / Development prospects

a. National level

Overview

X-ray free-electron lasers (XFELs) are a new generation of light sources offering novel experimental capabilities in diverse areas of science by providing very intense and tightly focused beams of x-rays with pulses ranging from 50 femtosecond to sub-femtosecond and wavelengths down to 0.1 nanometre. This time resolution is essential to investigate ultrafast dynamic processes in atomic and molecular structures since these processes are defined by the femtosecond vibration of an atom in a chemical bond. SwissFEL is designed to cover a wide range of x-ray energies. Phase I of the project was focused on the construction of the accelerator complex and the hard x-ray beamline ARAMIS. The civil construction was finished in 2014 and first pilot user experiments were performed in 2017. The pilot user operation and consolidation phase will continue until the end of 2018 followed by normal user operation starting in 2019. Phase II of the project, the ATHOS beamline, will expand the capabilities to soft x-rays (250 to 1900 eV) and will double the scientific capacity of SwissFEL. ATHOS will provide beams to two state-of-the-art experimental stations that are designed to make optimal use of the technical capabilities of SwissFEL, to attract national and international users and to foster scientific, technological and educational exchange within Switzerland and across borders. The ATHOS layout allows an extension to a third scientific instrument to be built after 2020. First light from ATHOS should be realised by the end of 2019 with first pilot user experiments expected for 2021. As a next-generation cutting-edge research infrastructure, ATHOS (together with ARAMIS, the Swiss Light Source (SLS) and its upgrade (SLS 2.0), as well as the Swiss Neutron Source (SINQ) and the Swiss Muon Source (SμS)) will play an important role in the scientific portfolio of Switzerland. Many of the research results produced at the ATHOS beamline will lead to important knowledge relevant to a large variety of fields, encompassing topics such as energy conversion, more efficient drug development and the design of smaller computer chips.

SwissFEL with its two beamlines ATHOS and ARAMIS will complement Swiss users' access to European XFEL, an international research organisation based in Hamburg of which Switzerland is a member.

Detailed description

ATHOS will add a second electron beam transport system to SwissFEL that will feed a variable-gap undulator line for producing soft x-ray laser beams. ATHOS will operate simultaneously with ARAMIS (energy range 1.8 keV – 12.4 keV) and will be optimised for producing radiation in the 250 - 1900 eV x-ray regime, with full polarisation control. This energy region covers absorption edges for the light elements oxygen, carbon and nitrogen, which play an important role in many chemical and biological processes, as well as those of the transition metals manganese, iron, cobalt, nickel, and copper, which are prominent components in classical and quantum devices. Also the absorption edge of silicon can be reached with ATHOS to cover the science related to semiconductor research.

A key feature of the ATHOS facility is the use of small magnetic chicanes between each undulator in order to manipulate the electron bunch during the lasing process, thus offering new capabilities beyond those implemented at operating facilities:

- Full control of soft x-ray polarisation (circular, linear, elliptical). Such a capability is extremely useful for the study of magnetic materials.
- Sub-femtosecond pulses with enough energy (above 100 μJ), which are very important for atomic, molecular and optical physics, as well as for non-linear x-ray optics.
- Parallel operation with ARAMIS at full 100 Hz rate. With a dedicated accelerating module in the ATHOS branch the electron bunch and photon beams in ATHOS can be rapidly tuned for its full photon energy range without disturbing ARAMIS operation.
- Simultaneous production of two-colour pulses with adjustable delay by splitting the 16 undulators in two sections separated by a delay chicane. Such pulses will be particularly convenient for performing stimulated resonant inelastic x-ray scattering (RIXS).

- Energy “broadband” mode providing a bandwidth up to 10% and the ultra-narrow bandwidth of the “high brightness” mode are unique operation schemes of ATHOS. Those capabilities will allow either the simultaneous measurement of orbital and spin moments by observing two absorption L-edges shot by shot, or high resolution RIXS with high transmission. Furthermore, it will allow the collection of single-shot RIXS spectra.
- Terahertz (THz) pump pulses for ATHOS that will be used to pump samples in two different ways: “B-field” to start magnetic dynamics, “E-field” to initiate chemical reactions on surfaces.

Access to ATHOS will be handled in the same manner as for the PSI existing facilities (selection of proposals for beamtime based on scientific excellence by an international review committee, access will be handled by the PSI User Office).

b. International level

The impact of XFELs, the new generation of x-ray radiation source, has been demonstrated so far by the first two XFELs in operation: LCLS at Stanford (operating since 2009), SACLA in Japan (operating since 2011) and European XFEL in Hamburg (operating since 2017). In 2017, first successful experiments were performed with SwissFEL, contributing to science development. Analogous to the other analytical research facilities of PSI, SwissFEL is open to the international research community. SwissFEL will provide a total of 5,000 hours’ beamtime per year and per FEL beamline (ATHOS and ARAMIS) at different experimental stations.

c. Development prospects

The implementation of ATHOS is done in a way that the interruptions in the operation of the ARAMIS branch is kept to a minimum level mainly combined with the necessary maintenance shutdowns of SwissFEL (3 times 3 weeks per year). Electron beam transmission through the first 110 m of ATHOS line has been recently demonstrated, as has the transport of two bunches in one radiofrequency pulse. The undulator prototype providing circularly polarised light is currently under assembly and will be tested by the end of 2018. The design of the light transport layout is close to completion and experimental stations are being designed in order to best fit the particularities of the ATHOS light. The Swiss research community will be able to benefit from this strategically relevant position of PSI at the forefront of these developments, since SwissFEL as the national facility is strongly oriented towards the research interests and expertise of Swiss researchers. Due to early and close collaboration between the SwissFEL project and industrial partners, Swiss industry will be able to transfer the acquired technological expertise to the market and allows them to play an internationally competitive leading role in the development of high-technology spin-off products.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 4 m	Canton 0	Canton 0
Swiss Confederation ETH Board: 40 m, PSI: 0.5 m	Swiss Confederation PSI: 15 m	Swiss Confederation PSI: 11 m
Third parties SNSF: 1 m Innosuisse: 0.65 m	Third parties SNSF: 1 m	Third parties SNSF: 1 m
Total budget **46.15 m**	**Total** **16 m**	**Total** **12 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 46.15 m Operating costs 0 Other costs 0	Investments 8 m Operating costs 8 m Other costs 0	Investments 4 m Operating costs 8 m Other costs 0
Total costs **46.15 m**	**Total** **16 m**	**Total** **12 m**

Development Phases	Years
Design	2016–2018
Preparation	2017–2018
Implementation	2019–2021
Operation	2021–2041

Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI)

Category: Technical infrastructures: (e-infrastructure, STEM)

Host institution(s): University of Geneva

Main funding sources: Swiss universities; State Secretariat of Education, Research and Innovation (SERI)

Description / Development prospects

a. National level

Overview

The Common Data Center Infrastructure (CDCI) was created in 2017 to foster the development of data centre activities in the context of both space-based and ground-based facilities dedicated astrophysics at large, i.e. including astroparticle and cosmology. The CDCI is based on 20 years of activities, starting with the establishment of the INTEGRAL Science Data Centre in Geneva, which is in charge of a significant fraction of the ground-segment operations of ESA's INTEGRAL space observatory. The CDCI envisages a major transformation in 2021 to increase its scope to include space weather and Earth observations activities, to cover the operational phases of the relevant missions with Swiss involvement, and to develop a significant computing infrastructure. The CDCI shall provide support to any Swiss scientist interested in leading data centre activities, in particular by contributing directly to the early phase of the missions. A major goal of the CDCI is to ensure the long-term preservation of the data and of the specific data analysis expertise after the mission is terminated, in particular through the deployment of web services.

Detailed description

The service infrastructure "Common Data Center Infrastructure (CDCI)" is the result of very significant activities at the University of Geneva (UNIGE) for the establishment, starting in 1995, of a data centre for ESA's X-ray and gamma-ray observatory INTEGRAL, the INTEGRAL Science Data Centre. This centre processes and archives the data from the INTEGRAL satellite and provides software to the community to allow any scientist to exploit the data. Thanks to this successful development, we developed a widely recognised expertise, which allowed us to start similar activities for a number of different space projects linked to astrophysics, including the ESA missions Planck, Gaia, CHEOPS and Euclid and the Swiss-Chinese mission POLAR. The participation in this project has been largely funded through specific programmes by the Confederation's Swiss Space Office. However, with the increase in the number of missions, the need for a dedicated infrastructure providing synergies between the different projects became quickly apparent. These synergies range from administrative management of the project, computer system administration, software and web services, to the software tools and approaches used in the development of such activities. The first goal of the CDCI is to ensure that a stable and efficient infrastructure can be offered to all projects of data centre developments for astrophysical space missions. The CDCI, being driven by scientific competence, also provides an opportunity to extend the data centre activities to any other domain related to astrophysics, like astroparticle and cosmology, including ground-based facilities. In order to increase its national relevance, starting in 2021, the CDCI shall also cover the related domains of space weather and Earth observations, and will be co-led by the University of Zurich.

The CDCI shall offer its services to all Swiss scientists interested in participating in data centre activities. In the early-development phases, before a dedicated team can be put in place, the CDCI will offer support to the scientists in the preparation of the Swiss contribution to the proposed missions, including the negotiations with the different partners and the preparation of the proposals. Different models of interactions between the team and the CDCI can be put in place, depending on the specifics of the project, and the proximity of the team in particular. Currently, INTEGRAL, POLAR, Gaia, CHEOPS, Euclid and CTA are directly benefiting from the services of the CDCI. When possible and when requested to do so by the mission's Swiss P.I., the CDCI will also directly contribute to software and algorithm development; it will provide the computing infrastructure and participate in the operations. The computing infrastructure will also be used for dedicated scientific computing programs.

Another of the CDCI's tasks is to serve data of current and past missions to the widest possible community with as much added value as possible. Most missions retain their scientific data many decades after the end of the mission. Without dedicated effort, this knowledge can disappear in little more than a few years. Furthermore, software ages, and becomes more and more difficult to install on new hardware. The CDCI

keeps alive the data of the missions it is involved in. This means not only maintaining the data archives and software, but also providing web services for running simplified and yet powerful and fully validated analyses. To this end, the CDCI will use modern software technologies, deploying containers on a cloud. The first development by the CDCI, the INTEGRAL Online Data Analysis, was released to the public at the end of 2018.

b. International level

Being at the service of missions that are most often the result of large international collaborations, the activities of the CDCI are very relevant on the international scene. Current activities are mostly concerned with space missions under the leadership of ESA. Several missions are done in collaboration with, or are led by, other space agencies, like NASA (USA), JAXA (Japan) or China. Ground-based facilities, space weather and Earth observations further extend international collaborations to new countries, in particular in South America (CTA), Oceania (SKA) and South Africa (SKA). The activities supported by the CDCI will give Switzerland high visibility in these projects.

c. Development prospects

Data centre activities for astrophysics at a significant level in Switzerland started with a unique mission, INTEGRAL. The University of Geneva and its Swiss partners have been very successful in obtaining significant participations in several space missions either in operation (INTEGRAL, Gaia) or in development (CHEOPS, Euclid). The CDCI already supports the candidate ESA Medium-size missions M5 SPICA and THESEUS, as well as the Large-size missions L2 Athena and L3 LISA. Several projects are currently under discussion with China, in particular the flagship mission eXTP. For ground-based facilities, the participation in CTA is already well advanced. Extensions of the CDCI will cover Earth observation's Swiss Data Cube and ARES projects. The current size of the CDCI is much too small in view of the wealth of data that will be generated by the new missions. In addition, the new projects will require a significant increase in the computing infrastructure. A large contribution will be obtained from the University of Zurich and from the Canton de Geneva.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 2.119 m	Higher Education Institution 3.74 m	Higher Education Institution 4.74 m
Canton 0	Canton 1.0 m	Canton 0
Swiss Confederation SERI/SSO: 1.787 m	Swiss Confederation [43]SERI (Art. 15): 4.74 m	Swiss Confederation [44]SERI (Art. 15): 4.74 m
Third parties ESA: 69 k (EUR 1.15)	Third parties 0	Third parties 0
Total budget **3.975 m**	**Total** **9.48 m**	**Total** **9.48 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 80k	Investments 1.2 m	Investments 1.2 m
Operating costs 3.895 m	Operating costs 8.28 m	Operating costs 8.28 m
Other costs 0	Other costs 0	Other costs 0
Total costs **3.975 m**	**Total** **9.48 m**	**Total** **9.48 m**

Development Phases	Years
Design	2014–2015
Preparation	2015–2016
Implementation	2016–2017
Operation	2017–2028

[43] Planned proposal for funding according to Article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Numbers can change as the proposal not submitted yet. Funding decision by EAER autumn/winter 2020.

[44] Planned proposal under Article 15 RIPA for the next period. Numbers can change as the proposal not submitted yet. Funding decision in autumn/winter 2024.

Center for Biomedical Research in Space

Category: Instruments and service infrastructure

Host institution(s): Lucerne University of Applied Sciences and Arts, Center of Competence in Biomedical Science & Technology

Main funding sources: Third party funding

Description / Development prospects

a. National level

Overview

The Center of Competence in Biomedical Science & Technology (CC BST) of the Institute of Medical Engineering at the Lucerne University of Applied Sciences and Arts is maintaining a new research infrastructure called “Center for Biomedical Research in Space” (CBRS). The unique CBRS allows an easy and uncomplicated access to low gravity research platforms for researchers, industry, and individuals in education.

The CC BST already maintains a registered ground-based facility of the European Space Agency ESA and in this function it is offering the instruments to researchers from all over Europe to conduct experiments under simulated/short-term microgravity conditions. The tasks that are conducted at the CBRS are to make use of our status at ESA but on a national level, and to carry out biomedical research under reduced gravity. At the same time, the CBRS is promoting microgravity research among scientists, companies and schools in Switzerland.

Detailed description

The core service of the CBRS provides access to several types of ground-based microgravity research platforms such as the Random Positioning Machine (RPM), parabolic flights performed by the Swiss Air Force and sounding rockets. Later on, additional microgravity research platforms will be added such as magnetic levitation, drop tower or flights with space carriers belonging to companies such as Space Applications Services or Virgin Galactic.

Furthermore, the CBRS services include the use of biological laboratories as well as dedicated e-infrastructures. The laboratories are of particular use to scientists who are investigating time-critical processes that require immediate post-processing after microgravity exposure. Another goal of the e-infrastructure is to create a permanent service data infrastructure that responds to the needs of exploitation of intensive data production under simulated and short-term microgravity conditions as well as to establish a flexible, extensible state-of-the-art service infrastructure that is able to provide support during the entire science work cycle.

The CBRS is a non-profit centre that is part of the legal entity of Lucerne University of Applied Sciences and Arts, School of Engineering & Architecture. The centre is available to everyone who is interested in conducting biomedical research under reduced gravitational loads. There will be an outreach programme in place to gain maximal visibility to the related science community as well as to the public.

b. International level

In the year 2000, the former Space Biology Group of ETH Zurich (today the CC BST) was appointed as one of the few official ground-based facilities of the European Space Agency ESA. Since then, we have been hosting international research groups for conducting their studies multiple times per year. The service we provide is paid for by the users. In addition, our work is honoured by being mentioned in scientific publications and in presentations at symposia or conventions. Being able to maintain the CBRS and expand the services further will attract even more researchers wishing to conduct their experiments in our centre.

c. Development prospects

The RPM is a frequently used instrument in laboratories all over the world and it is applied for investigating microgravity effects on biological systems, among other things. Its intense use is reflected

in the steadily increasing numbers of reports published every year in scientific journals. The CBRS thus aims at providing enough RPMs for the scientists.

An additional goal of the CBRS is to add new features to the RPMs, such as the ability to take microscopy pictures during operation. This broadens the operative range of the RPMs substantially, which increases the attractiveness of this instrument even more. Technological development will thus be fostered to incorporate more and more analytical tools into the RPM. To achieve this, cooperations will be established with leading Swiss research groups in technology at HSLU and elsewhere as well as with industry. There is no doubt that the technological developments will find their way into space or terrestrial applications.

Not only the RPM but other microgravity research platforms (as mentioned above) will be promoted similarly by the CBRS. In order to keep up with the demands of scientists on e-infrastructure, substantial effort will be put into establishing and maintaining a database that offers the latest features to the users.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 160,000	Higher Education Institution 180,000	Higher Education Institution tbd 200,000
Canton 200,000	Canton tbd 320,000	Canton tbd 400,000
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties Space Foundations 210,000	Third parties Space Foundations 180,000	Third parties Space Foundations tbd 190,000
Total budget 570,000	**Total 680,000**	**Total 790,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 200,000	Investments 240,000	Investments 280,000
Operating costs 360,000	Operating costs 420,000	Operating costs 480,000
Other costs 10,000	Other costs 20,000	Other costs 30,000
Total costs 570,000	**Total 680,000**	**Total 790,000**

Development Phases	Years
Design	2015–2016
Preparation	2016–2017
Implementation	2017–2019
Operation	2019–2028

Swiss Plasma Center (SPC)

Category: Instruments

Host institution(s): Ecole polytechnique fédérale de Lausanne

Main funding sources: (as of 2017): ETH Domain, EURATOM, ITER, SERI, SNSF, other including Innosuisse

Description / Development prospects

a. National level

Overview

The SPC is the major Swiss plasma and fusion laboratory. Its main goal is to contribute to the worldwide development of this new energy source through strong education and research programmes.

Detailed description

Research and development projects of the SPC are grouped into 6 research lines:
Theory of Plasmas, Basic Plasma Physics (experimental, TORPEX), Hot Plasmas Physics (fusion, tokamak, TCV), International collaborations, Superconductivity for Fusion and Plasma Applications.

Theory of Plasmas

Plasma is an extremely complex medium, characterised by phenomena that occur on a wide range of temporal and spatial scales, which are all nonlinearly coupled. Plasma theory activities aim to understand these physical phenomena mainly through first-principle based simulations.

Basic Plasma Physics (experimental, TORPEX)

The goal of the SPC Basic Plasma Physics group is to progress in the understanding of fundamental phenomena that occur in magnetised plasmas and that can have an impact in fusion energy research. It also provides a natural link between tokamak research and plasma theory, by offering an optimal environment for the validation of theoretical models, based on the toroidal device TORPEX.

Hot Plasmas Physics (fusion, tokamak, TCV)

The mission of the TCV programme is to apply its unique capabilities (plasma shaping, heating and current drive using waves in the electron cyclotron frequency range and neutral beams, advanced plasma control) to the exploration of the physics of magnetically confined plasmas, partly in direct support of the ITER project but also exploring some of the alternative paths that may be required beyond ITER on the way to DEMO, the first prototype fusion reactor.

International collaborations

Under this heading, besides the work in Superconductivity for Fusion, the SPC is also involved in activities in the field of electron cyclotron wave sources and antennas for ITER and DEMO, and the scientific exploitation of JET.

Superconductivity for Fusion

Activities in superconductivity are twofold. On one hand, the group carries tests of superconductors using the SULTAN device, the only installation worldwide capable of qualifying the superconductors used in fusion devices such as ITER. On the other hand, it participates in the design of superconducting coils for future installations such as DEMO and develops high temperature superconductors for fusion, medical applications, and advanced particle accelerators.

Plasma Applications

Applications of thermal and non-thermal plasmas in industry and society cover important technologies and markets such as semiconductor manufacturing, the packing industry, and solar cell production, and are being progressively extended to include agricultural, biological and medical applications.

b. International level

SPC contributes to the experimental campaigns carried out at JET, to the construction and the preparation of the scientific exploitation of ITER, and to the DEMO design. The TCV tokamak is one of the three national facilities (Switzerland, Germany, United Kingdom) that are operated in the context of the EURATOM Eurofusion Consortium.

c. Development prospects

Capitalising on the success of CRPP, the Swiss Plasma Center has been created, developing state-of-the art infrastructures and combining existing human resources at SPC with nation-wide synergies across interconnected areas of excellence, reinforcing the international aura and impact of Switzerland in plasma and fusion research. The main focus is on fusion, to enable EPFL to fulfil, on behalf of the Swiss Confederation, its role and obligations in the broader context of Europe, EURATOM and ITER. The aim is to improve our understanding and control capabilities of plasmas, covering both fundamental aspects and industrial applications. This investment enables the SPC to focus on two thrust areas:

TCV tokamak systems and related spin-offs

TCV is one of three national tokamak facilities rated as essential for the Fusion Roadmap, which aims at reaching electricity production from fusion energy by 2050. Three infrastructure enhancements are necessary to extend the relevance of TCV research for fusion power plants and the time horizon of the impact on the international fusion endeavour:

- a new diverter chamber, in the process of being inserted at the periphery of the plasma to achieve reactor relevant conditions and pioneer solutions to the crucial problem of plasma exhaust;
- two dual frequency gyrotrons for improving the plasma performance;
- a second 1 MW NBH system with high-energy capabilities, to study burning plasma regimes;
- improvements in diagnostic capabilities, with extended 2D coverage and potential for real time control.

Basic plasma physics and applications

The focus in this area is on plasma societal applications, with the aim of adapting present devices and acquiring new infrastructural elements to open the way to the exploration of environmental applications of plasmas, such as water purification, sterilisation, or plasma medicine. A bio-plasma laboratory has been started, which enables several synergies with local industries in the field of food and agriculture, and with UNIL and EPFL biology and life sciences research groups.

In general, the period through 2024, during which we do not anticipate major construction work, will be devoted to exploiting the present set of upgrades. As new experimental results will be collected, in our domestic campaigns and in the context of international collaborations, a strategic definition of the further steps for which the contribution of TCV would be crucial will become possible. These steps may involve additional infrastructural developments, such as the development of state-of-the-art adaptive diagnostics, a changeover in the TCV plasma facing materials, and the deployment of novel high-field magnet technologies for improving the attractiveness of the tokamak concept for reactor applications.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation EPFL: 70 m, ETH Board: 10 m; SERI: 4 m; PSI: 3 m	Swiss Confederation EPFL: 70 m; SERI: 4 m; PSI: 3 m	Swiss Confederation tbd
Third parties EURATOM: 20 m (EUR 1.15); ITER: 12 m; SNSF: 5 m; OTHER: 4 m	Third parties EURATOM: 20 m (EUR 1.15); ITER: 4 m; SNSF: 5 m; OTHER: 4 m	Third parties tbd
Total budget **128 m**	**Total** **110 m**	**Total** **tbd**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 30 m Operating costs 66 m Other costs 32 m	Investments 15 m Operating costs 65 m Other costs 30 m	Investments tbd Operating costs tdb Other costs tbd
Total costs **128 m**	**Total** **110 m**	**Total** **tbd**

Development Phases	Years
Design	2015–2018
Preparation	2017–2019
Implementation	2018–2020
Operation	2019–

National Research Centre for Animal Cognition

Category: Infrastructure

Host institution(s): University of Neuchatel

Main funding sources: University, City of La Chaux-de-Fonds, Third parties

Description / Development prospects

a. National level

Overview

Our general goal is to establish a research and education centre for studying animal intelligence. With this project, Switzerland will take a world-leading role in research in comparative cognition, support some of our national zoos in their mission to engage with research, enhance the public's understanding of scientific processes and establish new partnerships of excellence, notably by collaborating with research field stations in Africa. The project will be coordinated by the University of Neuchatel with an associated network of research stations in La Chaux-de-Fonds, Basel Zoo, Budongo Conservation Field Station (Uganda) and the Centre Suisse de Recherches Scientifiques (Ivory Coast). Our general vision is to carry out research in public view and link it with education. In Africa, we will be able to set up webcam links and to receive groups of university students and school children to carry out projects.

Detailed description

Our scientific plan is to ask fundamental research questions in ***comparative psychology,*** ultimately to better understand what makes us human. With 'comparative' we refer to an established method in evolutionary studies, that is, to reconstruct evolutionary history by investigating animal species with different degrees of relatedness and social organisation. With 'psychology' we refer to the scientific study of cognition and its physiological, behavioural and neural mechanisms. Our research aims at an evolutionary understanding of cognitive phenomena, such as economical decision-making, language and communication, reasoning, and social awareness. To this end, we propose to carry out non-invasive, behavioural studies with different species of primates and non-primates, chimpanzees, gorillas, orang-utans, sooty mangabeys, capuchin monkeys, dogs and wolves. All animal species will be housed as part of regular zoo exhibits or studied in their natural habitats.

Research facilities at Basel Zoo and at Zoo 'Bois du Petit Chateau' in La Chaux-de-Fonds consist of indoor compartments, specially designed indoor testing units, and spacious outside areas. In Africa, research facilities consist of specially equipped field stations for primate research to host researchers for long-term studies and small groups of visitors for short stays. Our request is to build new or modify existing infrastructure. **Unit 1** - great ape research facility at Basel Zoo (modification of existing infrastructure: completed); **Unit 2** - canine research facility near La Chaux-de-Fonds (new large outside area to house a pack of wolves, new indoor compartments with testing units for wolves and dogs); **Unit 3** - monkey research facility at Zoo du Bois du Petit-Château (hereafter ZBPC), La Chaux-de-Fonds (outside area to house two groups of monkeys, indoor compartments with testing units); **Unit 4** - field station Ivory Coast (www.csrs.ch - housing, lab and office space in Tai National Park): completed; **Unit 5** – field station Uganda (www.budongo.org - housing, lab and office space in Budongo Forest: completed). For Basel Zoo (unit 1), work has been completed with university funding. The primate facility in La Chaux-de-Fonds will require newly built infrastructure, adjacent to the ZBPC, to provide housing for one group of New World and Old World monkeys each, capuchin monkeys and sooty mangabeys (unit 3). For the canines (unit 2), our goal is to set up a similar testing facility suitable for domestic dogs and grey wolves. This will require new infrastructure in the vicinity of La Chaux-de-Fonds, also managed by the ZBPC. Additional office and storage rooms will be required, as well as space for public engagement activities. Work on the African field stations has been completed with university funding.

b. International level

In the US, the Yerkes Primate Center in Atlanta and the regional primate centre in Bastrop regularly carry out cognition research. Both Lincoln Park Zoo and the National Zoo in Washington have facilities where the public can observe behavioural experiments with great apes. Japan has also invested heavily in animal cognition with a Primate Research Institute housing approximately 500 primates. In Europe, France has several centres in Strasbourg, Aix, and Rennes. In Germany, the Max-Planck Society has

established an institute in Leipzig in addition to the German Primate Research Centre in Göttingen. In the UK, Edinburgh Zoo hosts two research units devoted to primate cognition, the Living-Links and Budongo Trail research facilities, and there are plans to develop a similar facility for birds. For canine cognition (dogs and wolves), world-leading facilities are the Wolf Science Center and the Clever Dog Lab at the University of Vienna, the Family Dog Project in Budapest, and the dog cognition laboratory at Duke University. All these facilities are based on studying the natural behaviour of intact animals non-invasively. No comparable facilities exist in Switzerland, apart from the University of Fribourg, which keeps primates for highly invasive experimentation, which is not suitable for behaviourally based cognitive studies nor for public understanding of science purposes.

c. Development prospects

The proposed facilities offer multiple advantages for future research. First, it will offer standardised testing procedures that will eliminate experimenter bias. Second, due to automated and voluntary access, sample sizes will become very large, allowing for more powerful statistical analyses than currently used in such studies. Third, comparing multiple species in their cognitive performance will enable us to carry out comparative studies to identify evolutionary and co-evolutionary trends. Fourth, we will aim to integrate research across various disciplines, including neurosciences, economics and behavioural ethology, while taking advantage of the latest methodological advances, such as eye-tracking, infrared-based pupil dilation, remote body tracking and electroencephalography (EEG and event-related potentials (ERPs)) technologies. Finally, the direct link with fieldwork will inform our research about the functional significance of the observed behavioural phenomena.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 270,000	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 0	Third parties 3,446,667	Third parties 1,000,000
Total budget 270,000	**Total 3,446,667**	**Total 1,000,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 270,000	Investments 3,446,667	Investments 1,000,000
Operating costs 0	Operating costs 0	Operating costs 0
Other costs0 0	Other costs 0	Other costs 0
Total costs 270,000	**Total 3,446,667**	**Total 1,000,000**

Development Phases	Years
Design	2021–2022
Preparation	2022–2023
Implementation	2023–2024
Operation	2024–2028

Swiss Research Network of Clinical Paediatric Hubs (SwissPedNet)

Category: Service infrastructure (Data / Service Centres: Clinical research specific services)

Host institution(s): Mainly hospitals[45].
Main funding sources: Host institutions

Description / Development prospects

a. National level

Overview
SwissPedNet is a nation-wide research organisation consisting of Clinical Paediatric Hubs located at the nine largest (university) paediatric hospitals of Switzerland, a central coordination office at the SCTO, a central infrastructure for registries (SwissPedRegistry), the research infrastructure providing services in paediatric pharmacology (SwissPedPha). SwissPedPha utilises developmental and paediatric pharmacology expertise and applies advanced pharmacometric modelling and simulation approaches to support and enhance design and analysis of clinical trials conducted by one or several SwissPedNet hubs.

Each paediatric hub has age- and development-appropriate infrastructures (clinical facilities for children) and is staffed by pediatrics-trained personnel, guaranteeing the quality aspects for research in children.

Detailed description
While being dedicated to children, paediatric hubs are locally closely linked to the SCTO Clinical Trial Units (CTUs) network, sharing non-paediatric-specific aspects of clinical research with the corresponding facilities for adults. To allow for resource-saving synergies, SwissPedNet's central office is located within the SCTO Executive Office.

SwissPedNet will be able to integrate and support most of the existing, disease- or organ-specific research networks and paediatric cohorts in Switzerland and thus to achieve further efficiency and to address the manifold aspects of clinical research. Several interfaces/links with already existing and proposed infrastructures, organisations and projects are already established or ready for cooperation. The overall objective is to further develop, professionalise and fortify the national structures (SwissPedRegistry, SwissPedPha) and the nine existing Clinical Pediatric Hub structures. Key tasks of SwissPedPha are to improve quality of designs of paediatric studies conducted by SwissPedNet and to optimise analyses of data generated within SwissPedNet. Positions for research associates and paediatric study nurses are a prerequisite at each hub to guarantee good clinical practice (GCP) compliance and assure all quality and safety aspects in clinical pediatric research.

b. International level

SwissPedNet has been a member of Enpr-EMA, the European Network of Paediatric Research at the European Medicines Agency, since February 27, 2013. Enpr-EMA works by allowing networking and collaboration with members from within and outside the European Union (EU), including academia and the pharmaceutical industry.

SwissPedNet is member of the consortium in two European infrastructure projects funded by Horizon2020: (1) PedCRIN is the paediatric branch of ECRIN and aims to develop capacity for the management of multinational pediatric non-commercial clinical trials (2017–2020). (2) Id-EPTRI (European Paediatric Translational Research Infrastructure) is a new complementary RI in the context of the existing RIs intended to putting together and networking all the available competences and technologies useful to enhance research into paediatric medicines from drug discovery and early development phases to be translated into clinical phases and medicines uses.

SwissPedNet is member of the consortium of the IMI2 funded project c4c/conect4children: the collaborative network for European clinical trials for children is a project for the development,

[45] Kantonsspital Aarau, Klinik für Kinder und Jugendliche; Universitäts-Kinderspital beider Basel; Ente Ospedaliero Cantonale, Pediatria, Bellinzona; Inselspital Bern, Kinderkliniken; Hôpitaux Universitaires Genève, Hôpital des Enfants; Centre Hospitalier Universitaire Vaudois, Département femme-mère-enfant; Luzerner Kantonsspital, Kinderspital Luzern; Ostschweizer Kinderspital St Gallen; Universitäts-Kinderspital Zürich; Institut für Sozial- und Präventivmedizin, Universität Bern, SwissPedRegistry; Pediatric Pharmacology and Pharmacometrics Research Center at Universitäts-Kinderspital beider Basel, SwissPedPha

implementation and evaluation of robust, sustainable and integrated pan-European network trial delivery. Since its inception SwissPedPha has been recognised internationally and this has resulted in collaborations with several European countries such as Belgium, Norway, Germany and the Netherlands. Until now these collaborations have focused on the unique expertise of SwissPedPha in advanced pharmacometric modelling and simulation as well as developmental pharmacology. The existing collaborations have resulted in multiple joint publications and the training of international master and PhD students in Switzerland. The opportunity provided by the funding of SwissPedPha has raised Switzerland's visibility in this field and made it one of the top three countries in Europe in the discipline of paediatric pharmacology and pharmacometrics, along with France and the Netherlands.

c. Development prospects

The current funding of CHF 71,000 per institution per year enables the hubs to employ 0.5–0.6 FTEs in national clinical research. Many activities in paediatrics are still being developed. As soon as processes become more established and more multicentre clinical studies come to Switzerland, this amount of funding will be insufficient and it will become necessary to increase staffing to 0.8–1.0 FTE at each hub, which will require an additional CHF 539,000 in funding per year, or CHF 2.156 million over the whole funding period.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 6,100,000	Higher Education Institution 2,508,163	Higher Education Institution 2,508,163
Canton 3,500,000	Canton 8,727,400	Canton 8,727,400
Swiss Confederation SERI (SCTO[46]): 3,124,000	Swiss Confederation SERI (SCTO[47]): 5,280,000	Swiss Confederation SERI (SCTO[48]): 5,438,400
Third parties 0	Third parties 2,010,000	Third parties 2,010,000
Total budget 12,724,000	**Total 18,525,563**	**Total 18,683,963**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0 Operating costs 12,724,000 Other costs 0	Investments 0 Operating costs 18,525,563 Other costs 0	Investments 0 Operating costs 18,683,963 Other costs 0
Total costs 12,724,000	**Total 18,525,536**	**Total 18,683,963**

Development Phases	Years
Design	2011
Preparation	2012
Implementation	2012–2016
Operation	2017–

[46] SCTO: Swiss Clinical Trial Organisation supported by SERI (Art. 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). SCTO received CHF 14 million for 2017–2020 (Art. 15 RIPA) and allocated CHF 3.124 million to SwissPedNet.

[47] The SCTO will apply for CHF 21.4 million for the 2021–2024 period (Art. 15 RIPA) and plans to allocate CHF 5.28 million to SwissPedNet. Numbers may change as the proposal has not yet been submitted.

[48] The SCTO plans to allocate CHF 5.438 million to SwissPedNet from the funding it receives under Art. 15 (RIPA) in 2025–2028 (unknown).

Swiss Center for Musculoskeletal Biobanking and Imaging and Clinical Movement Analysis (Balgrist campus)

Category: Technology Competence Center

Host institution(s): Balgrist Campus AG

Main funding sources: Donations, SERI (Art. 15 RIPA), rental income and user contributions

Description / Development prospects

a. National level

Overview

Balgrist Campus is an initiative of the ResOrtho Foundation, which is dedicated to the creation of an optimal infrastructure for musculoskeletal research and education, and of the Schweizerischer Verein Balgrist, a not-for-profit organisation whose mission is to improve the care of the musculoskeletal patient. Balgrist Campus has established a Swiss platform for nationwide research, development, and translation in the field of musculoskeletal science and medicine to the benefit of musculoskeletal patients of today and tomorrow, closing the loop between understanding of musculoskeletal disorders and treatment. The core facilities of this musculoskeletal research and development centre include:

The **Swiss Center for Musculoskeletal Biobanking (SCMB):** This platform forms the hub of a nationally accessible (multi-centre clinical) network for the indexing, archiving, analysing, and cataloguing of anonymous but well documented human tissue for musculoskeletal research.

The **Swiss Center for Musculoskeletal Imaging (SCMI):** This is a diagnostic imaging research core facility, which ultimately envisions musculoskeletal imaging from the molecule to the moving body, leveraging the world-leading musculoskeletal radiology centre at the University Hospital Balgrist.

The **Swiss Center for Clinical Movement Analysis (SCMA):** This is a centre dedicated to the functional analysis of musculoskeletal organs and tissues based on movement analysis.

These elements form three pillars of a scientific centre serving as an open-access repository for patient-specific data and derivative analytics and as an open access research infrastructure for musculoskeletal disorders of large socioeconomic importance to Switzerland.

Detailed description

Balgrist Campus plugs a substantial gap in the Swiss research landscape by providing an environment dedicated to connecting academic research and industry. Its association with a leading academic clinical centre holds large potential for addressing the burden of musculoskeletal diseases, by serving as a national hub for basic and applied research as well as for the development of strategies of prevention, diagnosis and treatment of musculoskeletal injury and disease.

This project is of national importance: Approximately 18% of all Swiss hospitalisations are directly related to musculoskeletal disorders. The project focuses on a subject of worldwide socio-economic relevance, and has the potential to contribute to relieving the burden of musculoskeletal disease; Switzerland is particularly suited to serve this purpose as modern orthopaedic medicine has largely been shaped by Swiss academic leaders, but also by the extraordinarily well-developed Swiss biotechnological industry. Balgrist Campus consolidates this national strength and builds upon it.

Balgrist Campus hosts a number of research groups from across Switzerland as well as industrial partners. This setting incorporates partners from research hospitals contributing to multi-centre studies, including the targeted banking of patient tissues for thorough molecular and cellular characterisation. The research network includes engineers, clinical scientists, epidemiologists, and others seeking to understand musculoskeletal problems and translate gained understanding into viable clinical solutions. Research infrastructure within the Balgrist Campus is available to external Swiss research institutions on a cost-contribution basis.

In contrast to other national research institutions, the Balgrist Campus focuses exclusively on musculoskeletal disorders – a fact which makes the research infrastructures at the Balgrist Campus particularly well suited and uniquely powerful. The base of this power comes both from the physical connection of the Campus to a major Swiss Orthopaedic and Paraplegic clinical centre, as well as from an already existing critical mass of musculoskeletal research and development in Zurich.

Balgrist Campus opened in December 2015 and reached full capacity within three years. Three additional research infrastructures were constructed and are fully operational as of November 2018. The ETH Zurich, the Balgrist University Hospital, the University of Zurich and the Zurich University Hospital have relocated personnel to the Campus. Collaborations exist with multiple national research groups at the University of Zurich, the University of Basel, EPFL and with several industrial partners.

In 2017 the Balgrist Beteiligungs-AG was established at Balgrist Campus to support innovative development projects and their transition to start-up companies. Within the first two years, five start-ups have been supported and several patent applications submitted. The collaboration with established medtech companies has already led to the sale of one of the projects and to two licensing arrangements.

b. International level

The infrastructure, the unique proximity to the clinical environment and well documented patient data repositories already draw international scientists to the Campus. In 2017, Prof. Sam Ward, University of California San Diego, visited Balgrist Campus under the "guest sabbatical" programme. In 2019, Prof. Nassir Navab, TU Munich is invited to continue the international collaboration on the topic of musculoskeletal health. Several international commercial partners, currently from Germany and Canada, have decided to relocate some of their employees and equipment to Balgrist Campus. Most recently, Siemens Healthineers have decided to place two employees on the Campus to support the translation of research results into clinical application.

c. Development prospects

In early 2019, the Children's Hospital of Zurich relocated research groups to the Campus, intensifying and enlarging collaboration between the university medical institutions. The research infrastructures at the Balgrist Campus have already enabled affiliated investigators and their national and international collaborators to apply for research project funding at the Swiss National Science Foundation, the EUH2020 program, and the U.S. National Institutes of Health.
The SCMB at Balgrist Campus is participating in a SNSF application which aims to establish a multi-centre biobank IT infrastructure. This direct IT connection between biobanks is focusing on the secure handling of sensitive medical data in order to protect the privacy and confidentiality.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 13.1 m	Higher Education Institution 13.5 m	Higher Education Institution 13.5 m
Canton Lottery fund 9.0 m	Canton tbd	Canton tbd
Swiss Confederation SERI (Article15): 15.4 m	Swiss Confederation [49]SERI (Article 15): 18.4 m	Swiss Confederation tbd
Third parties ResOrtho&Balgrist Foundations 68.3 m	Third parties User costs & Balgrist Foundations 5 m	Third parties User cost contributions 7.4 m
Total budget 105.8 m	**Total 36.9 m**	**Total 20.9 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 87.9 m	Investments 11.8 m	Investments tbd
Operating costs 17.4 m	Operating costs 24.6 m	Operating costs 20.9 m
Other costs 0.5 m	Other costs 0.5 m	Other costs 0
Total costs 105.8 m	**Total 36.9 m**	**Total 20.9 m**

Development Phases	Years
Design	2015–2016
Preparation	2017
Implementation	2018
Operation	2019–

[49] Planned funding proposal under Article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Funding decision by EAER in autumn/winter 2020.

Neuchâtel Platform for Analytical Chemistry (NPAC)

Category: Technical infrastructure

Host institution(s): University of Neuchâtel

Main funding sources: University of Neuchâtel (leading house), users (academic and research institutions, industries)

Description / Development prospects

a. National level

Overview

The Neuchâtel Platform for Analytical Chemistry (NPAC) was created in 2014 as the result of a merger between the UniNE chemical analytical facilities and the chemical analytical service of the *Swiss Plant Science Web*. NPAC now performs chemical analytical services for all Swiss universities, federal research institutions and industries. The aim is to expand NPAC in order for it to become Switzerland's top platform, as well as one of the world's leading centres in chemical analytics and metabolomics. This requires an investment in reinforcing and expanding the platform's analytical capabilities, ensuring that NPAC will perform to its full potential.

Detailed description

The analytical service at the University of Neuchâtel currently performs more than 25,000 analyses per year and greatly facilitates the research of scientists and industries throughout Switzerland and beyond. The platform uses state-of-the-art liquid chromatography (LC) and gas chromatography (GC), mass spectrometry (MS) and nuclear magnetic resonance spectroscopy (NMR) in order to support research on the isolation, characterisation, identification and quantification of bioactive molecules of scientific and practical interest. In the last five years, NPAC has collaborated with more than 70 research groups from all Swiss universities, as well as from several federal and foreign research institutions, resulting in more than 95 peer-reviewed publications. We wish to further develop the NPAC facilities and expand the platform to make it one of the world's leading centres in chemical analytics applied to biological samples, in particular from plants. As such, NPAC can greatly advance national and international research in a field that is of utmost importance to industry, agriculture, and the protection of the environment. This requires reinforcement with additional personnel and state-of-the-art equipment.

b. International level

Advances in chemical analytical technologies, in particular in the field of metabolomics, have greatly increased the potential to help scientists to discover novel biologically active compounds. This has been particularly successful in the field of plant sciences, and the University of Neuchâtel, in the context of the NCCR *Plant Survival*, has greatly contributed to these recent developments at an international level. We can claim that there is no equivalent research infrastructure devoted to plant sciences in Switzerland. Within Europe, several institutions, such as the Max Planck Institute for Chemical Ecology (Jena, Germany), and the University of Leiden (The Netherlands) have comparable infrastructures, but they are less devoted to serve other research groups and in some cases even rely on our help. For example, more than 25% of all the scientific publications of NPAC in the last five years have been produced in collaboration with researchers outside Switzerland. Hence, NPAC is already recognised worldwide as one of the top analytical services.

c. Development prospects

In the table below we indicate the commitment by UniNE and the additional funding that we expect to obtain from other sources (SNSF, industries etc.). With these investments we will be able to optimise the platform's capacity, as it would allow NPAC to obtain the most advanced technologies that are currently available and enable it to handle the expected increase in the number of samples to analyse. Since the 2015 Roadmap, the University of Neuchâtel has fully honoured its commitments and made the following specific investments:

Appointment of a technician (100%) in 2015 (UniNE funding)

Purchase of a gas chromatograph coupled to a mass spectrometer in 2015 (CHF 95,000, UniNE funding)
Purchase of a micro-UHPLC tandem MS in 2015 (CHF 420,000, UniNE funding)

In addition, the following investments are now foreseen for the period 2017–2020:

Appointment of a second technician (40%), will be filled in October 2018 (UniNE funding)
Purchase of a 600 MHz NMR (CHF 1,000,000) in 2019 (UniNE + third party funding)
Purchase of a UHPLC-high resolution MS (CHF 600,000) in 2019 (UniNE + SNF R'Equip)
Purchase of a second gas chromatography-mass spectrometry system (CHF 200,000) in 2019 (ERC grant funding)
Purchase of a proton transfer reaction mass spectrometer (CHF 300,000) in 2019 (ERC grant funding)

With the above purchases NPAC will have all the equipment that is needed to operate at its full potential, and for the period 2021–2024 only one additional replacement is foreseen:

Purchase of a UHPLC-tandem MS (CHF 550,000) in 2023 (third party funding)

For the period 2025–2028, an increase in funding is needed to upgrade or replace obsolete equipment, and to invest in next-generation technological breakthroughs that will become commercially available.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 1,836,000	Higher Education Institution 624,000	Higher Education Institution 857,000
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 1,300,000	Third parties 555,000	Third parties 1,500,000
Total budget 3,136,000	**Total 1,174,000**	**Total 2,357,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 3,415,000 Operating costs 521,000 Other costs 0	Investments 550,000 Operating costs 624,000 Other costs 0	Investments 1,700,000 Operating costs 657,000 Other costs 0
Total costs 3,136,000	**Total 1,174,000**	**Total 2,357,000**

Development Phases	Years
Design	2013
Preparation	2013–2015
Implementation	2015–2027
Operation	2015–2028

Information and computational service infrastructure network to support biomedical research in Switzerland (BioMedIT)

Category: Information and service infrastructures

Host institution(s): SIB Swiss Institute of Bioinformatics, in collaboration with the universities of Basel, Lausanne, Bern, Geneva, Zurich, and associated university hospitals; Swiss TPH; ETH Zurich and Lausanne; university of applied science HES-SO.

Main funding sources: Structural funds from participating universities and associated university hospitals, contributions by large scale research projects; State Secretariat of Education, Research and Innovation (SERI)

Description / Development prospects

a. National level

Overview

Over the last decade, new disruptive technologies (e.g. in genetics, genomics, imaging, proteomics, microfluidics, nanotechnologies, portable/implantable measurement devices, 'big data' AI/ML techniques etc.) have changed the paradigms for biomedical research and are about to fundamentally transform healthcare and medicine. In order to enable research and translation of the wealth of data produced by such modern technologies into medical practice and new treatments, strong capabilities in clinical bioinformatics, computational biology and secure computational service infrastructure are required. Besides biomedical research, other areas of research such as social sciences are increasingly processing confidential personal information and are therefore faced with similar challenges of IT security and data protection.

BioMedIT has been established as a nationwide distributed network of core facilities with central coordination, providing secure computational infrastructures, services, and competences for research in Switzerland. The project builds on existing expertise and research infrastructure in the partnering institutions by extending their capacity and capabilities. BioMedIT is managed by the SIB Swiss Institute of Bioinformatics and is tightly integrated with the activities of the Data Coordination Center of the Swiss Personalized Health Network (SPHN) initiative of the Confederation. While the implementation is driven by biomedical applications, the resulting secure RI network has a broad range of applications beyond life sciences.

Detailed description

Most current research IT facilities at Swiss universities are tailored towards handling basic research data with little constraints on IT security and data protection requirements. However, biomedical research using personal data from citizens and patients (e.g. clinical data, genomics, tracking and sensor data) imposes very high requirements to the IT infrastructure and expertise, which differ substantially from all-purpose research infrastructures. BioMedIT extends the capacity and capabilities of research IT facilities at Swiss universities to meet the needs of translational biomedical research, especially in the context of SPHN. By establishing mechanisms enabling nationwide exchange of health-related data (e.g. harmonisation of data semantics, exchange formats, etc.) SPHN will also allow using health data in research.

BioMedIT has been established as a nationwide distributed network of core facilities with central coordination, providing secure computational infrastructure, services, and competences for biomedical research in Switzerland. Participating nodes operate their infrastructures based on common standards for IT security, apply common mechanisms for secure data exchange between hospitals and research institutions, and will provide interoperable software and data analysis workflow execution capabilities across the network. Currently, BioMedIT high-performance computing and storage infrastructure is located at three distributed sites (SIS ETH Zürich, sciCORE University of Basel, and Vital-IT SIB Lausanne / Geneva) which provide ICT services to all members of the network. Additional sites may join the network in the future. Specific software projects are performed decentrally at various partner sites, according to the local technical and scientific competences.

National collaborations include the SDSC Swiss Data Science Center on the development of workflows for secure reproducible data analysis, and the PHRT platforms on management and processing of omics data for personalised health research.

BioMedIT is managed by the SIB Swiss Institute of Bioinformatics under the responsibility of the BioMedIT Board, closely coordinated with the SPHN Data Coordination Centre. Working groups on IT Security, Workflow Interoperability and Bioinformatics and Data Analytics provide guidance on future developments.

b. International level

The SIB represents the Swiss node of ELIXIR – an initiative to coordinate Bioinformatics infrastructures in Europe – and BioMedIT thereby closely collaborates with other European partners in this area. Of particular note are efforts for harmonising identity and access management (IAM) mechanisms across European research institutions (ELIXIR AAI), workflow execution interoperability, and the development of a decentralised federated version of the European Genome-phenome Archive (EGA). BioMedIT recently started collaboration with colleagues in Germany and Netherland towards the development of a platform for distributed privacy-preserving data analysis (Personal Health Train) making use of FAIR data access points.

c. Development prospects

The main focus of the first phase of the BioMedIT project (2017–2020) is on establishing a nationwide distributed network of core facilities with central coordination, operating under the same policies, establishing secure and performant computational infrastructure, and developing and implementing concepts for service interoperability. In the second phase (2021–2024) it is expected that the scope of SPHN will extend beyond the current set of partner hospitals to include health information from other data providers, healthy citizens, sensors and wearables, and large scale *omics projects. This will require corresponding further development of the ICT infrastructure network during this phase.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 11.1 m	Higher Education Institution 11.1 m	Higher Education Institution 8.4 m
Canton 0	Canton 0	Canton 0
Swiss Confederation SERI (Art. 15): 18.5 m	Swiss Confederation [50]SERI (Art. 15): 18.5 m	Swiss Confederation [51]SERI (Art. 15): 14.1 m
Third parties 1.5 m	Third parties 1.5 m	Third parties 1.5 m
Total budget 31.1 m	**Total 31.1 m**	**Total 24.0 m**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 6.0 m Operating costs 25.1 m Other costs 0	Investments 6 m Operating costs 25.1 m Other costs 0	Investments 6 m Operating costs 18.0 m Other costs 0
Total costs 31.1 m	**Total 31.1 m**	**Total 24.0 m**

Development Phases	Years
Design	2017
Preparation	2017
Implementation	2018–2024
Operation	2025–2028

[50] Planned proposal by SIB for funding under Article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Funding decision by EAER autumn/winter 2020.

[51] Planned proposal under Article 15 RIPA for the next period. Funding decision in autumn/winter 2024.

The Swiss edu-ID and the Swiss Academic Cloud based on the Academic Network SWITCHlan

Category: Distributed

Host institution(s): SWITCH Foundation

Main funding sources: SWITCH's funding scheme is built on contributions of the community and of Swiss and European research funding bodies as well as SWITCH own equities. As the community fully pays for running services, new projects and innovations are supported by additional, national and international funds and own means.

Description / Development prospects

a. National level

Overview

SWITCH is a foundation of the Swiss universities, whose mission is to provide outstanding information and communication services (e-infrastructures) to research and education. The e-infrastructure of SWITCH consists of three principal parts, which complete with each other in an ideal way: SWITCHlan as the physical network layer, SWITCHengines as the infrastructure layer and SWITCHedu-ID (AAI) as the middleware layer. As such, SWITCH has moved towards an integration of networks, cloud infrastructure and ID/access services and continues to improve its functionality in order to present an integrated offering to the user.

Detailed description

SWITCHlan: As a physical link, SWITCHlan brings together universities and research institutions from all over Switzerland (http://www.switch.ch/network/). SWITCH has built this education and research network on its own and is constantly developing it further. Stable internet access, the rapid and secure exchange of data at 100 Gigabit/second and an excellent connection to international networks – SWITCH offers all of this from a single source. Our SWITCHlan education and research network provides the high-quality communication infrastructure that is required for meaningful cooperation and exchange across national borders. To protect the network and the exchange of scientific information, SWITCH runs a computer emergency response team (CERT), which is constantly expanding its security services in the university environment. SWITCH-CERT is in a position to take effective action in the event of security emergencies – also if they extend beyond national borders.

SWITCHengines: provides computing and storage services in the form of virtual machines to researchers, lecturers and IT services of Swiss universities and related institutions. This infrastructure meets the special needs and national regulations for academic computing and information management. SWITCH contributes its cloud infrastructure to support the research community - along with e-science and IT teams in universities. Its components are located in Zurich and in Lausanne.

SWITCHaai: is based on the concept of federated identity management. It was established between 2000 and 2015 in Switzerland's higher education sector. Today, it gives over 300,000 users access to over 1,000 services. Since 2016 SWITCH has been working together with its partners, the Swiss universities, to migrate the organisation-centric SWITCHaai identity management system into the user-centric SWITCH edu-ID. To address the trends of life-long learning, increased mobility and collaboration needs, SWITCH edu-ID issues permanent identities with scalable quality in an extensible framework. An established identity management system across all academic institutions is a mandatory prerequisite for providing user-uniform access to services.

b. International level

SWITCHlan: On the international level, the SWITCH network team is a project partner in the GEANT-Project (www.geant.org). GEANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs). GEANT connects over 50 million users at 10,000 institutions across Europe.

SWITCHengines: We collaborate in continuing development of open source products (most notably OpenStack, Ceph and newly Kubernetes).

SWITCHaai: supports interfederation, which means that SWITCHaai users can also access services which authorise international users. This programme is part of the GEANT project, supported by the European Union.

c. Development prospects

SWITCHlan has laid the foundations for the development until 2020 and beyond. In the 2020–2024 period the network will undergo incremental improvements in specific locations and we expect individual institutions to upgrade their connectivity to higher bandwidths. It should also be noted that the benefits of the upgrade consist not only of increased bandwidth and improved resilience, but also in new functionality and flexibility. On the international level, SWITCH will continue its participation in the series of GEANT projects within the Horizon 2020 framework, and currently plans to contribute to GN4-3. SWITCH-CERT is continuously extending and improving its detection and response capabilities as well as the accuracy of the Swiss threat landscape. In addition, SWITCH-CERT works with the community on development of further managed security services.
SWITCHengines is being run as a production quality cloud infrastructure. The supported functionality is being continuously extended according to the users' needs. Most recent new services comprise a dedicated administrative user interface custom-tailored to the needs of universities and support for virtual private cloud technology (L2 connectivity between campus and engines networks) and container technology. The service infrastructure is being expanded according to the growth of its usage.
SWITCHaai: The development concentrates on two avenues. First and foremost it coordinates and supports institutions in adopting the edu-ID. Secondly, it enhances the supported functionality of edu-ID in various ways beyond what is possible with SWITCHaai today. This creates a strong motivation for the institutions to adopt the edu-ID.
Remark on costs: The costs of SWITCHlan and of the SWITCHaai / SWITCH edu-ID infrastructure are not available as the participating institutions do not publish the costs arising for them. The following figures contain the central part of SWITCH only. For this infrastructure, which provides all running services, full costs are covered by the institutions in higher education and research (universities, universities of applied sciences, universities of teacher education). Some subsidies come from the EC via Horizon 2020 and the next framework European framework programme. The investments are written off and therefore included in the operating costs.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 51,500,000	Higher Education Institution 60,800,000	Higher Education Institution 67,000,000
Canton 0	Canton 0	Canton 0
Swiss Confederation [52]PgB-5: 2,000,000	Swiss Confederation PgB: 1,000,000	Swiss Confederation PgB: 2,000,000
Third parties EU: 1,500,000	Third parties EU: 1,000,000	Third parties EU: 1,000,000
Total budget 55,000,000	**Total 62,800,000**	**Total 70,000,000**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments N/A Operating costs N/A Other costs N/A	Investments 11,600,000 Operating costs 62,800,000 Other costs 0	Investments tbd Operating costs tbd Other costs tbd
Total costs 55,000,000	**Total 62,800,000**	**Total 70,000,000**

Development Phases	Years
Design	Ongoing
Preparation	N/A
Implementation	N/A
Operation	2017–2028 and beyond

[52] PgB-5: Projects financed under Article 59 (project contributions) of the Federal Act on Funding and Coordination of the Swiss Higher Education Sector.

Swiss Data Science Center (SDSC)

Category: Information and Service Infrastructure
Host institution(s): EPFL and ETH Zurich
Main funding sources: ETH Domain
Description / Development prospects

a. National level

Overview

The ETH Domain launched the Initiative for Data Science in Switzerland (IDSS) in 2015 to strengthen data science through education and research and the provision of infrastructure. Within this initiative, EPFL and ETH Zurich initiated the Swiss Data Science Center (SDSC) and now jointly lead and operate the Center in close collaboration with the research institutes of the ETH Domain. The Center's mission is to accelerate the adoption of data science and machine learning techniques within the academic community at large as well as in industry. The SDSC is composed of a multi-disciplinary team of data and computer scientists plus experts in selected domains, with offices in Lausanne and Zurich. By breaking down disciplinary boundaries, the SDSC acts as a real interface and service layer for data science projects while addressing transverse security and privacy issues, enabling multidisciplinary collaborations.

Detailed description

The SDSC supports data science research projects focusing on in-depth data analysis in specific scientific domains and on the development of technology and methods for data science research. The SDSC aims to facilitate a strong synergy between data providers, data and computer scientists and specialists in specific fields, fostering scientific breakthroughs with significant societal impact. Projects showing an interdisciplinary character i.e. linking research groups from traditionally separated disciplines are privileged. Ongoing projects cover a broad range of scientific fields, such as physics, biology (incl. medicine), environmental sciences, computer science and economics.

The SDSC is developing RENKU, an open-source software platform designed to facilitate the exchange of data and knowledge between all the actors involved in data science collaborations, while allowing them to enforce their respective data management plans. During the initial phase, data, methods and publications generated by various academic projects feed the analytics platform. The platform will ultimately create an international community to share data, tools, methods and information in a federated environment.

RENKU offers:

- Reproducibility
  RENKU fosters reproducible research by enabling scientists to retrieve history and data provenance, and go back in time to every step of published science.
- Reusability and repetition
  The platform facilitates the sharing and reuse of data and algorithms, and empowers specialists to use other people's work in their own projects and execute them in an infrastructure-agnostic environment. Attributions are therefore also consistently guaranteed.
- Collaboration
  RENKU supports a collaborative environment for dynamic and interactive prototyping by enabling content-rich discussions.
- Security
  RENKU makes use of state-of-the-art security and privacy preserving technologies and best practices. It will give fine grained control over who accesses any data, from where and how.
- Federation
  RENKU is designed to connect independently administered platforms and positions itself as a unique one-stop shop for high quality data by allowing federated access across institutions, giving each the freedom to enforce its own access controls over resources.
- Discovery

Thanks to its automatically maintained and enriched knowledge graph, the platform supports targeted exploration as well as unforeseen discoveries by giving scientists access to the big picture through interconnected metadata.
RENKU is an open-access platform operated on a cost-recovery basis for academic users. The access policy for industry users is currently being developed.

b. International level

At a time when data science has become extremely important, with the majority of top-tier international research and teaching institutions investing significantly in dedicated centres and programmes, the successful launch of the SDSC lays the foundation of a truly national Data Science Center striving to be globally competitive. Discussions are currently taking place with international universities about a potential adoption of RENKU.

c. Development prospects

Thanks to its unique structure, the SDSC, jointly initiated and lead by EPFL and ETH Zurich and closely collaborating with the research institutes of the ETH domain, brings together the expertise of leading researchers throughout the country. The SDSC will extend the reach and visibility to national and international academic institutions and accelerate the adoption of data science by (Swiss) industry. There are currently 20 ongoing academic projects fostering the use of RENKU, and the centre is expected to go up to 40 projects.

d. Costs (in CHF)

2017–2020	2021–2024	2025–2028
Higher Education Institution 0	Higher Education Institution tbd	Higher Education Institution tbd
Canton 0	Canton tbd	Canton tbd
Swiss Confederation ETH Board: 30 m EPFL, ETHZ: 5.7 m	Swiss Confederation ETH Board: 40 m EPFL, ETHZ: tbd	Swiss Confederation tbd
Third parties Users/Grants: 7.3 m	Third parties tbd	Third parties tbd
Total budget **43 m**	**Total** **tbd**	**Total** **tbd**
Costs overview (2017–2020)	**2021–2024**	**2025–2028**
Investments 0 Operating costs 30 m Other costs 13 m	Investments tbd Operating costs tbd Other costs tbd	Investments tbd Operating costs tbd Other costs tbd
Total costs **43 m**	**Total** **tbd**	**Total** **tbd**

Development Phases	Years
Design	2014–2015
Preparation	2015–2016
Implementation	2017–2018
Operation	2018–2024 and beyond

2019 Swiss Roadmap for Research Infrastructures

Annex B

Annex B1: Participations in international research infrastructures for consideration

Foreword

Infrastructures in which Switzerland already participates:

- European Plate Observing System (EPOS ERIC)
- European Clinical Research Infrastructure Network (ECRIN ERIC)
- Integrated Carbon Observation System (ICOS ERIC)
- Biobanking and molecular resources research infrastructure (BBMRI ERIC)
- Consortium of European Social Science Data Archives (CESSDA ERIC)
- European Social Survey (ESSurvey ERIC)
- Survey of Health, Ageing and Retirement in Europe (SHARE ERIC)
- Partnership for Advanced Computing in Europe (PRACE)
- Laboratory Infrastructure (ECCSEL ERIC)

Infrastructures in which Switzerland has shown an interest:

- Aerosol, Clouds, and Trace gases (ACTRIS)
- Digital Research Infrastructure for the Arts and Humanities (DARIAH ERIC)
- European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER)
- Extreme Light Infrastructure (ELI)

NB:

1) **The financial information given below reflects the planning figures provided by the higher education institutions/infrastructure management.**
2) **The financial figures in this document for the ERI periods 2021–2024 and 2025–2028 are forecasts and are only given as a rough estimate of probable future costs and how they will be allocated.**
3) **Last information update: January 2019**

European Plate Observing System ERIC (EPOS)

Legal form: *ERIC*

Main funding sources: *Host state, member states, EU structural funds*

Funding in Switzerland:

Funding projection	Total CH share[53] (CHF m)	Participation fees[54] (CHF m)
2017–2020	2.05	0.33
2021–2024	4.10	0.65
2025–2028	4.46	0.78

Description

The European Plate Observing System ERIC (EPOS, www.epos-eu.org) creates a single sustainable, permanent observational infrastructure for Earth sciences, integrating existing geophysical monitoring networks (e.g. seismic and geodetic networks), local observatories (e.g. volcano observatories) and experimental laboratories (e.g. experimental and analytic lab for rock physics and tectonic analogue modelling) in Europe and adjacent regions. It coordinates the currently scattered, but highly advanced, European facilities into one distributed, coherent multidisciplinary research infrastructure and promotes innovative approaches for a better understanding of the physical processes controlling earthquakes, volcanic eruptions and tsunamis, as well as those driving tectonics and Earth surface dynamics.

The EPOS infrastructures provide key parameters for the multi-disciplinary study of the interior structure, composition and dynamics of the Earth, for exploration activities related to the identification and exploitation of natural and energy resources and for the assessment and monitoring of natural hazards. In addition to Earth scientists modelling the structure and processes in the Earth's interior, users of EPOS data include engineers and private practitioners, federal and cantonal offices, the construction industry, critical infrastructures, and the insurance sector. EPOS has been included as a landmark in the 2018 ESFRI roadmap (http://roadmap2018.esfri.eu/projects-and-landmarks/browse-the-catalogue/epos/) and the EPOS ERIC was established late 2018 with Switzerland as a founding observer.

National relevance

EPOS offers a unified framework, platforms and tools to provide access to data and products from the main Swiss research and monitoring infrastructures to Swiss and European researchers and service agencies, covering earthquake data, geodetic and geological mapping, geomagnetic and remote sensing data, near-fault multiparameter data, data collected in laboratories (rock deformation, geochemistry, volcanology) and deep underground laboratories and geoenergy testbeds for low carbon energy. In addition to its academic impact, EPOS thus secures data access at European level to deliver monitoring services that are of national interest and related to federal tasks. EPOS data and activities also provide a key contribution to the development of geothermal technologies and safe underground waste storage, for the implementation of Switzerland's energy, climate and climate adaptation strategies.

Within EPOS, Switzerland coordinates the domain of seismology, leads the development of the new European harmonised earthquake hazard model and provides Virtual Access to earthquake hazard information through the European Facilities for Earthquake Hazard and Risk (www.efehr.org). It also provides transnational access to the Bedretto Underground Laboratory (experimental facility for reservoir stimulation, geoenergy technologies and earthquake physics) and to the experimental rock physics laboratories at ETHZ and EPFL, operates one of the European data distribution nodes for access to seismological waveform data, and provides Virtual Access to the multiparameter data collected by the Near Fault Observatory in Valais.

[53] The total includes the participation fees and the provision of European-level services within EPOS, and is contributed mainly by ETHZ, EPFL and other Swiss universities.

[54] The participation fees from 2021 onwards will form part of the 2021–2024 ERI Dispatch. For 2019/2020 the participation fees are covered by ETH Zurich.

European Clinical Research Infrastructure Network ERIC (ECRIN)

Legal form: *ERIC*

Main funding sources: *Member states, Project (trials) specific funding (H2020, IMI, ERA-Nets, EDCTP and other*

Funding in Switzerland:

Funding projection	Total CH share[55] (CHF m)	Participation fees[56] (CHF m)
2017–2020	0.57	0.11
2021–2024	0.69	0.22
2025–2028	0.69	0.22

Description

The European Clinical Research Infrastructure Network (ECRIN, https://www.ecrin.org/) is a non-profit, intergovernmental organisation that supports multinational clinical trials in Europe. Multi-country trials provide increased access to patients, resources, and expertise, and, in turn, potentially more robust trial results and greater public health impact.

ECRIN, which has the legal status of an ERIC, is a network of networks that connects research facilities at multiple sites in countries across Europe and provides support and services for top-level multinational clinical research. The organisational model is based on country memberships and has currently 11 members with Switzerland as an observer, represented by the SCTO. Switzerland has participated in ECRIN since its beginnings - the development phases were FP6 & FP7 European Framework Programme funded projects - and Swiss researchers have full access to ECRIN services and support.

Each member country hosts a European Correspondent, who is at the heart of the national networks, managing the clinical trial portfolio and coordinating with the national scientific partner (i.e. network of clinical trial units, or CTUs) with the support of the Paris-based Core Team.

With a focus on investigator-led, academic studies, ECRIN provides consultancies, services and tools for clinical trial preparation, protocol review and trial management services, helping scientists to find their way through Europe's fragmented health and legal systems in the latest scientific and legal environment. ECRIN provides freely accessible tools and standards as well as clinical research centre certifications (data management, pharmacovigilance) and maintains a regulatory database (Campus, http://campus.ecrin.org/).

National relevance

ECRIN membership provides multiple advantages including full access to ECRIN management and consultancy services independent of the pathology concerned. Provided at no additional cost, these services support countries to achieve ECRIN's mission of developing and implementing multi-site, multinational clinical trials.

The structure of the SCTO perfectly fits the ECRIN terms for a national hub. With its CTU network the SCTO provides a unique infrastructure available in this field in Switzerland. The Swiss academic research community benefits from increased research and trial collaboration opportunities and greater patient access, and so attractively and competitively positions Swiss clinical research in the international competition with respect to innovation and quality.

Moreover, sharing best practices and resources among national scientific ECRIN partners creates considerable added value for the academic research community, saving potential costs. Participation in ECRIN furthermore ensures early access to information about regulatory changes in clinical research in Europe.

[55] The total includes the participation fees and personal costs (contributed mainly by SERI via Article 15).

[56] The participation fees from 2021 onward will come under the 2021–2024 ERI Dispatch.

Integrated Carbon Observation System ERIC (ICOS)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH share[57] (CHF m)	Participation fees[58] (CHF m)
2017–2020	6.68	0.30
2021–2024	6.78	0.32
2025–2028	7.01	0.32

Description

The Integrated Carbon Observation System (ICOS, https://www.icos-ri.eu/) provides high-precision, long-term and standardised observations of the carbon cycle, namely of greenhouse gases (GHG) in the atmosphere and of their exchange between atmosphere, ecosystems and oceans. GHG emissions and carbon sinks on the European continent can only be quantified by means of such integrated and highly harmonised measurements, which also facilitate research relevant to the mitigation of and adaptation to anthropogenic climate change. The ICOS European Research Infrastructure Consortium (ICOS ERIC) became operational on 23 November 2015. ICOS ERIC currently consists of 12 European member and observer countries (such as Switzerland) with their own national networks (with more than 100 measurements stations overall). ICOS ERIC's Head Office is located in Helsinki. ICOS data and data products are fully open access, following the FAIR principles, available at the ICOS Carbon Portal (the one-stop shop for all ICOS data and data products). Data will thus not only stimulate scientific studies and modelling efforts, but also provide science-based information to stakeholders and user communities, responding to global demands such as those of the Paris Agreement and the UN Sustainable Development Goals, as well as to national policies.

ICOS Switzerland (ICOS-CH) is the Swiss contribution to the ICOS research infrastructure (ICOS RI). The ICOS-CH consortium consists of ETH Zurich (National Focal Point), Empa, WSL, University of Bern, University of Basel and MeteoSwiss. ICOS-CH contributes to ICOS RI with two Class 1 stations, i.e. those of the most advanced category: one atmospheric station (Jungfraujoch, JFJ) and one ecosystem station (Davos, DAV). JFJ was officially certified as ICOS Class 1 atmosphere station in May 2018, while DAV expects to receive the ICOS Class 1 ecosystem station certification in early 2019. Both stations are unique in terms of their geographical location. JFJ is the highest permanently manned research station in Europe (3453 m a.s.l.), while DAV is currently the only sub-alpine (1639 m a.s.l.) Candidate Class 1 forest station within ICOS. Long-term observational data are one of the main pillars of the ICOS RI, to which the two Swiss ICOS stations contribute with an outstanding measurement history (JFJ: since 1974; DAV: since 1997). These valuable contributions must be continued by complying with the now established ICOS RI standards, and with a time horizon of 20 years.

National relevance

ICOS-CH (www.icos-switzerland.ch) with the two unique measurements stations and its exceptional geographical location in the central part of the Alps is an out-standing node within the ICOS RI network. Similarly, the scientific excellence of ICOS-CH partners is highly visible within ICOS RI and beyond, and attracts new scientific collaborations. Moreover, ICOS-CH profits from intense scientific exchange with other leading European experts and direct access to central services, including calibration facilities, cutting-edge data processing, and a dedicated outreach, dissemination and communication strategy. Furthermore, participation in ICOS RI allows Switzerland to actively shape the future scientific agenda in Europe and beyond with respect to carbon cycle and greenhouse gas research. By providing standardised data, ICOS-CH supports policies designed to meet the resolutions of the Paris Agreement to mitigate climate change.

[57] The total includes the participation fees and is contributed mainly by SNSF, with further contributions by all partners, i.e. ETH Zurich, Empa, WSL, MeteoSwiss, and the universities of Bern and Basel.

[58] The participation fees are paid currently by SNSF.

Biobanking and Molecular Resources Research Infrastructure ERIC (BBMRI)

Legal form: *ERIC*

Main funding sources: *Host state, member states, EU structural funds, participation in EU programs*

Funding in Switzerland:

Funding projection	Total CH share[59] (CHF m)	Participation fees[60] (CHF m)
2017–2020	0.12	0.12
2021–2024	0.26	0.13
2025–2028	0.26	0.13

Description

BBMRI-ERIC (http://www.bbmri-eric.eu/) aims to develop a pan-European distributed research infrastructure in order to facilitate access to high quality (biological) resources and facilities for biomolecular and biomedical research purposes. Essential for the understanding of the diversity of human diseases, biological material stored in biobanks and the corresponding data are considered as the essential raw material for the advancement of biotechnology and personalised medicine. To coordinate international biobanking activities and increase samples and data quality making biobanks interoperable and accessible, BBMRI-ERIC is establishing services and tools for users and owners of biobanks.

BBMRI-ERIC is engaging with numerous stakeholders: the European Union, researchers, institutions, patient organisations, standardisation organisations, other research infrastructures, health and research ministries, biobanking intiatives and societies. 19 countries participate as members (Austria, Belgium, Czech Republic, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Malta, the Netherlands, Norway, Sweden, and the United Kingdom), 4 as observers (Switzerland, Cyprus, Poland and Turkey) and one international organisation (International Agency for Research on Cancer (IARC)/WHO) also participates.

The relevant scientific partners in using BBMRI-ERIC in Switzerland are:

- Swiss Biobanking Platform: as the national node of BBMRI-ERIC and the national reference on biobanking activities. Networking through SBP, the research community in biology and health in Switzerland are the users of the BBMRI-ERIC services.
- The SNSF, indirectly through SBP, by introducing minimal biobanking standards as a requirement in research instruments

National relevance

In Switzerland, biobanks operate with heterogeneous processes, are not registered, making the search and comparability for samples difficult and their use critical due to compatibility issues. Moreover, biobanking practice has greatly evolved over the last years, from the individual collection of biological material to professional infrastructures dealing with ethical, legal, accessibility and data sharing, reproducibility, data protection and quality issues leading to a dramatic increase in the costs of biobanking activities. Swiss Biobanking Platform has been created by the SNSF in order to respond to the needs of the Swiss research community in terms of coordination and harmonisation of biobanking activities in multiple fields of research by increasing the visibility, quality, transparency, accessibility and interoperability of biobanks. These needs concur with the long-term efforts of the SNSF to foster excellent research in biology and medicine. SBP aims at being the reference platform for biobanking activities in Switzerland, by providing services to the research community linked to BBMRI-ERIC. In this respect, promoting harmonised processes and coordination of biobanking activities in Switzerland must be made following international standards to allow Swiss researchers and institutions to enter the European network and benefit from the tools developed by BBMRI-ERIC.

[59] The total includes the participation fees.

[60] It is intended that the participation fees will be paid by SNSF through the budget allocated to SBP.

Consortium of European Social Science Data Archives ERIC (CESSDA)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH share[61] (CHF m)	Participation fees[62] (CHF m)
2017–2020	6.45	0.12
2021–2024	7.90	0.13
2025–2028	8.52	0.13

Description

The provision of social science data and metadata is vital to our understanding of the major challenges facing society today. The Consortium of European Social Science Data Archives (CESSDA, https://www.cessda.eu/) has the mission of building on existing national infrastructure within the member countries and strengthening and expanding the pan-European network of social science data archives. CESSDA members (Switzerland has the status of observer) seek to enhance the scientific excellence and efficacy of European research in the social sciences, as well as to facilitate access to data and metadata regardless of national borders.

CESSDA was recognised by the European Strategic Forum for Research Infrastructures (ESFRI) and included in the ESFRI Roadmap in 2006. It was pronounced an ESFRI Landmark in 2016. The European Commission set up the CESSDA infrastructure as a European Research Infrastructure Consortium (CESSDA ERIC) under Council Regulation (EC) No 723/2009 on 9 June 2017. The governance and operation of the CESSDA consortium is based on the CESSDA statutes and annexes, according to which each member of the consortium must appoint a national service provider that performs CESSDA tasks in the country. The Service Providers must meet the specific demands and requirements set out in the CESSDA statutes and must be appropriately supported (financially and operationally) by the individual member state's ministry of research or delegated institution. The major part of the development work of CESSDA ERIC is performed by the 17 National Service Providers.

National relevance

A principal goal of CESSDA is to provide full-scale sustainable research infrastructure that enables the research community to conduct high-quality research, leading to effective solutions to major challenges facing society. To achieve this, CESSDA supports national and international research and cooperation in the social, economic and political sciences, corresponding to the European long-term strategic document "Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth".

CESSDA supports social science research across the European Research Area (ERA) by providing, on a not-for-profit basis, a comprehensive and integrated social science data research infrastructure that facilitates and supports research, teaching, and learning throughout the social sciences and beyond. This is achieved through the development and coordination of standards, protocols, and professional best practices pertaining to the preservation and dissemination of data and associated digital objects, and by facilitating researchers' access to relevant resources of the European social science research community. CESSDA provides effective leadership and serves as a catalyst for change across its area of interest by supporting member and partner organisations and enabling them to derive maximum benefit from membership; it openly and constructively engages with its various user communities (researchers as data producers and data users, funding bodies across EU, and its own Service Providers) and works with other stakeholders for their mutual benefit.

The total contribution for CESSDA in the budget includes the costs of the "Data and research information services (DARIS)" located at FORS, the Swiss National Service Provider for CESSDA.

[61] The total includes the participation fees and is contributed mainly by SNSF.

[62] The participation fees through the contribution to FORS (Article 15, RIPA); part of the SNSF budget from 2021 (portfolio reorganisation).

European Social Survey ERIC (ESSurvey)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH share[63] (CHF m)	Participation fees[64] (CHF m)
2017–2020	2.9	0.43
2021–2024	2.9	0.43
2025–2028	3.0	0.43

Description

The European Social Survey (ESS, https://www.europeansocialsurvey.org/) is a pan-European research infrastructure providing freely accessible data for academics, policymakers, civil society and the wider public. This academically driven cross-national survey has been conducted across Europe since its establishment in 2001. In 2013 the ESS was acquired ERIC status (European Research Infrastructure Consortium), and in 2016 was recognised as an ESFRI Landmark. As of end of 2018, the ESS ERIC comprises 23 member countries, 1 observer country (Switzerland) and 4 confirmed guest countries, making it the Research Infrastructure Consortium with most members.

The ESS has become a gold standard for comparative surveys in the social sciences, known for its high methodological quality standards, and very widely used. Every two years, face-to-face interviews are conducted with newly selected, cross-sectional samples. The survey measures the attitudes, beliefs and behaviour patterns of diverse populations in more than thirty nations. The ESS data is available free of charge for non-commercial purposes. ESS has over 130,000 registered users, and over 3,000 identified publications. **National relevance**

Switzerland has participated in each round of the European Social Survey to date, thanks to the continuous financial support of the Swiss National Science Foundation. Thanks to the uninterrupted, high quality and timely prepared Swiss datasets, Switzerland's data are included in a very large proportion of publications using ESS data. Furthermore, Switzerland's ESS team and other Swiss researchers are very present in the international community related to this survey, and the country contributes to major methodological and substantial discussions in the social sciences. Over 4,000 out of 130,000 registered users are from Switzerland, and nearly 7,600 ESS datasets have been distributed so far to Swiss users.

In order to guarantee the continuation and expansion of the impact of ESS data from and in Switzerland, we have to continue to ensure the production of high quality data with comprehensive documentation and the timely delivery of the data for inclusion in the first international release. Furthermore, it must be noted that the work with ESS data by the Swiss ESS team and their presentations of the survey in academic and public arenas, as well as their contribution of expertise to the central ESS, contribute to the impact of this outstanding survey, both at home and abroad.

[63] The total includes the participation fees and is contributed mainly by SNSF.

[64] The participation fees through the contribution to FORS (Article 15, RIPA) and will be a part of the SNSF budget from 2021 (portfolio reorganisation).

Survey of Health, Ageing and Retirement in Europe ERIC (SHARE)

Legal form: *ERIC*

Main funding sources: *Host states, member states, EU structural funds, Grant from National Institute on Aging (NIA), H2020 INFRA programme*

Funding in Switzerland:

Funding projection	Total CH share[65] (CHF m)	Participation fees (CHF m)
2017–2020	3.8	0.05
2021–2024	3.8	0.1
2025–2028	Project ends in 2024	Project ends in 2024

Description

The Survey of Health, Ageing and Retirement in Europe (SHARE; http://www.share-project.org/organisation/share-eric.html) is a multidisciplinary and cross-national panel database of microdata on health, socio-economic status and social and family networks. In biennial survey waves, people aged 50 or older from 27 European countries and Israel are interviewed. The first wave of SHARE was conducted in 2004 as a representative survey and has since been repeated every two years with an increasing number of countries participating. Overall, more than 297,000 interviews with more than 120,000 individuals have been conducted in survey waves 1 to 7. The data are available to the entire research community free of charge.

With SHARE, data researchers can provide better understanding of how individuals and families are affected by ageing. SHARE exploits Europe as a "natural laboratory" to investigate the population ageing process and brings together many scientific disciplines, including demography, economics, biology and statistics. The results of the research can be used by science and politics in finding solutions to the challenges of our social security and health care systems.

National relevance

Population ageing is also a reality in Switzerland and a challenge at all levels as well. As in all European countries, it puts the pension system under strain, increases health costs and puts social cohesion at risk. In view of the reforms and adaptations that are currently implemented, discussed or envisaged, SHARE is an important source of evidence which will help society to better cope with the challenges in the health, employment and social sectors. SHARE data provide an overview of the current situation and allow us to monitor changes; they also allow us to examine the impact of specific reforms on the elderly population in general or on different specific groups. As such, SHARE data and the analyses based upon them are an important source of evidence which helps countries with an ageing population to better design policy measures.

Thanks to the continuing financial support of the Swiss National Science Foundation, Switzerland has participated in each round of SHARE since its beginnings in 2004 (Switzerland has an observer status in SHARE ERIC). This has contributed to the consistent provision of data by very high quality to researchers. Thanks to uninterrupted, high quality and timely prepared Swiss datasets, Switzerland's data are included in a very large proportion of publications using SHARE data. The Swiss data are used by both Swiss researchers and researchers working abroad. Indeed, a large majority of the publications involve comparative analyses and include the Swiss data as well. In addition, thanks to easy access to the data and the popularity of the survey, the SHARE data are also a reference for international contextualisation and very often used in publications for this purpose, for example by the OECD or WHO, helping to raise Switzerland's profile on the international scene. In Switzerland, the SHARE data are also a reference for institutes such as Obsan or statistical offices, which provide a statistical support for the Confederation, the cantons and other institutions.

[65] The total includes the participation fees and is contributed mainly by SNSF.

Digital Research Infrastructure for the Arts and Humanities ERIC (DARIAH)

Legal form: *ERIC*

Main funding sources: *Member states, H2020 DESIR (2017-2019, European Research funds); SAGW*

Funding in Switzerland:

Funding projection	Total CH share[66] (CHF m)	Participation fees (CHF m)
2017–2020	0.14	-
2021–2024	0.70	0.22
2025–2028	0.72	0.24

Description

DARIAH (https://www.dariah.eu/) is an acronym for Digital Research Infrastructure for the Arts and Humanities. It provides a framework for pan-European cooperation among research infrastructures for researchers in the humanities working with computer-based methods. It promotes digital research as well as the teaching of digital research methods. Since 15 August 2014, DARIAH has been organised as a European Research Infrastructure Consortium (ERIC). Currently 17 countries are full members of DARIAH; they constitute the General Assembly. Switzerland is not member currently of the ERIC DARIAH, but nine academic institutions are Cooperating Partners of DARIAH. In order to coordinate the DARIAH-relevant activities in Switzerland in an efficient way, the universities of Basel, Bern, Geneva, Lausanne, Neuchâtel, Zurich, the EPFL and the SAHS created the DARIAH-CH consortium on 30 October 2018. The purposes of the consortium are to prepare the national infrastructure of DARIAH-CH from 2021 onwards by establishing and financing a Swiss National Point of Contact.

National relevance

Well-designed research infrastructures form one of the most important strategic goals of the European Research Area. A remarkable sign of this development is, for example, the aim to establish by 2020 a common cloud for research data in Europe, the European Open Science Cloud. Open Science, and related to that, Open Data and the FAIR Data Principles including suitable data management procedures, are the main challenges facing the humanities and cultural studies fields in the near future. Moreover, the skilful use of digital methods in the humanities is still not part of the general knowledge of the majority of Swiss students and researchers, although efforts have been made or are being planned by several Swiss universities and the EPFL to found Digital Humanities Labs (Basel, EPFL, Geneva, Lausanne, Zurich) or programmes or doctoral schools for the digital humanities (DH).

In this situation, the Swiss humanities research landscape needs collaborative international partnership. DARIAH is the most powerful network of research infrastructures and humanities researchers in Europe, which can be joined to get support in meeting the above-mentioned challenges. For Switzerland as non-EU-member state, cooperation in European programmes can frequently be challenging. DARIAH allows Swiss researchers to get involved on a national level with a European research community without the disadvantage of a special status or restrictions. The list below shows the advantages for members:

- involvement in European research, infrastructure programmes and flagship projects in the DH;
- participation in the strategic bodies of DARIAH without restriction;
- clustering effect for communities by establishing a national coordination office;
- exchange of know-how in digital methods and infrastructures for the humanities;
- higher visibility for successful national DH-projects on a European level.

[66] The total includes the participation fees, due to be paid by the SNSF, and the costs for the Swiss coordinating office, paid by the DARIAH-CH consortium from 2021, and a preparation step paid by the H2020 project DESIR in 2017-2019.

Partnership for Advanced Computing in Europe (PRACE)

Legal form: *Association*

Main funding sources: *Member states*

Funding in Switzerland:

Funding projection	Total CH share[67] (CHF m)	Participation fees[68] (CHF m)
2017–2020	2.62	0.24
2021–2024	2.62	0.28
2025–2028	2.62	0.28

Description

The mission of PRACE (Partnership for Advanced Computing in Europe, http://www.prace-ri.eu/) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. The objective of PRACE is the provision of a persistent pan-European High-Performance Computing ("HPC") service and infrastructure, which will be managed as a single non-profit European entity ("PRACE AISBL"). PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact.

The PRACE AISBL was established in 2010. The PRACE AISBL will enable the provision of world class computer services to the key scientific and industrial communities in Europe and it is of utmost importance to the PRACE Council that the PRACE AISBL continues successfully. The initial objectives of PRACE which have been expressed in the "Memorandum of Understanding concerning the establishment of a European Tier-0 High Performance Computing Service", signed in 2007, remain the same during PRACE 2.

The computer systems and their operations accessible through PRACE are provided by 5 PRACE members (BSC representing Spain, CINECA representing Italy, ETH Zurich/CSCS representing Switzerland, GCS representing Germany and GENCI representing France). Four hosting members secured funding for the initial period from 2010 to 2015. In 2016 a fifth Hosting Member, ETH Zurich/CSCS (Switzerland) opened its system via the PRACE peer review process to researchers from academia and industry.

The PRACE project partners have received or are receiving EC funding under the PRACE Preparatory and Implementation Phase Projects (PRACE-1IP, 2010-2012, RI-261557 | PRACE-2IP, 2011-2013, RI-283493 | PRACE-3IP, 2012-2017, RI-312763 | PRACE-4IP, 2015-2017, 653838 | PRACE-5IP, 2017-2019, 730913). The total funding of the PRACE projects amounts to EUR 132 m over 10 years (2010 – 2019), of which EUR 97m is provided by the European Commission (EC).

National relevance

Being part of the PRACE RI has a number of advantages for Switzerland:

- Swiss scientists receive access to extreme-scale computing resources of different architectures;
- The visibility and quality of the Swiss Tier-0 programme (formerly called CHRONOS) will be enhanced being part of a wider frame;
- The support structure (level 2 and 3) for the Tier-0 allocations is funded by the general partners and will be considered a consolidated contribution to the User Lab;
- The level 3 support for projects that can be candidate Tier 0 will help scientists in Switzerland and elsewhere in Europe to attain more ambitious goals at scale.

[67] The total includes the participation fees and is contributed mainly by ETHZ.

[68] The participation fees are paid by ETHZ.

European Carbon Dioxide Capture and Storage Laboratory Infrastructure ERIC (ECCSEL)

Legal form: *ERIC*

Main funding sources: *Member states*

Funding in Switzerland:

Funding projection	Total CH share[69] (CHF m)	Participation fees[70] (CHF m)
2017–2020	1.16	0.08
2021–2024	4.58	0.26
2025–2028	4.56	0.24

Description

ECCSEL (http://www.eccsel.org/about/eccsel-eric/) was established in June 2017 to enable cutting-edge research on Carbon Dioxide Capture and Storage (CCS) technologies, to enable low to zero CO_2 emissions from power generation and industry to mitigate climate change. ECCSEL is a pan-European distributed research infrastructure, i.e. an ERIC (European Research Infrastructure Consortium). ECCSEL's main objectives are to: 1) establish and operate a world class distributed CCS Research Infrastructure in Europe; 2) integrate, upgrade and build CCS research facilities; 3) enhance European science, technology development, innovation and education in the field of CCS; 4) enhance technology transfer, foster innovation, enable spin-off activities and generate new business.

Within the initial 5 European founding member countries (France, Italy, the Netherlands, UK and Norway (Operations Centre, in Trondheim)), 13 service providers offer researchers across the globe easy access to 56 world class research facilities across Europe (see http://www.eccsel.org/ for a detailed list). ECCSEL is expected to grow in terms both of member countries and of major investments for both upgraded and new facilities. ECCSEL ERIC already comprises unique infrastructure for the study of CCS from the basic lab scale to the demonstration and piloting phase.

National relevance

All climate change mitigation scenarios acknowledge the key role that CCS systems will have in the next decades not only to mitigate carbon dioxide emissions but also to enable the active removal of carbon dioxide from the atmosphere. Over the last two decades, Swiss researchers and Swiss industry have been playing an important role at the national, European and international level to advance the science and engineering of CCS systems. Swiss research institutions can contribute unique experimental facilities to ECCSEL, such as geo-mechanical characterisation infrastructure, set-ups for the study of CO_2 capture processes, underground laboratories to conduct CO_2 injection/storage field tests (the three underground laboratories at the Grimsel Test Site, Mont Terry Rock Laboratory and Bedretto laboratory).

This situation makes Swiss participation in the ECCSEL-ERIC both extremely effective and useful. Moreover, it makes the yearly investments of the Swiss federal offices (primarily the SFOE and swisstopo) in national and international programmes on CCS and on research infrastructure that serves the CCS scientific community (the underground laboratories mentioned above) even more productive.

Belonging to the ECCSEL consortium and community enables Swiss researchers to be key contributors to the international efforts in developing and demonstrating CCS technologies. This in turn helps the Swiss community to participate with scientific weight in international projects, initiatives and negotiations. At the national level, it attracts interest as well as additional research funds from both the public and the private sector. It is clear that, as it develops and gains new partners, new experimental facilities and scientific and political weight, being part of ECCSEL will be crucial not only from a scientific point of view but also from the practical perspective of finding feasible solutions to cope with Swiss greenhouse gas emissions and to enable the deployment of negative emissions solutions.

[69] The total includes the participation fees and is contributed mainly by institutions of the ETH Domain, namely ETH Zurich, EPF Lausanne and Paul Scherrer Institute, by the PIs involved, as well as by swisstopo (for underground laboratory infrastructure).

[70] The participation fees will be paid by SERI from 2021 (till 2020 paid by ETHZ and other Swiss partners).

Aerosol, Clouds, and Trace Gases (ACTRIS)

Legal form: *ERIC (foreseen)*

Main funding sources: *Host state, member states, EU structural funds, Research performing institutions participating in hosting ACTRIS facilities.*

Funding in Switzerland:

Funding projection	Total CH share[71] (CHF m)	SERI[72] (CHF m)
2017–2020	4.86	-
2021–2024	11.14	5.09
2025–2028	10.8	5.00

Description

Atmospheric composition and processes play a vital role in environmental and societal challenges such as air quality, adverse health impacts or climate change. ACTRIS-RI (Aerosols, Clouds and Trace gases Research Infrastructure, https://www.actris.eu/) is a pan-European initiative to consolidate permanent and long-term observations of aerosols, clouds and trace gases at distributed National Facilities. ACTRIS-RI is composed of observing stations, instrument calibration centres, and a data centre, as well as exploratory platforms (https://www.eurochamp.org/Eurochamp2020.aspx). ACTRIS-RI is due to be fully operational as an ERIC (European Research Infrastructure Consortium) by 2025.

Switzerland contributes to ACTRIS through the following facilities: Jungfraujoch is a world-leading station, equipped with the best instruments for measuring aerosols and trace gases, and complemented by lidar ceilometer observations from Kleine Scheidegg. The observations from this renowned remote location will be complemented by measurements on the Swiss Plateau at Payerne and Beromünster, providing in-situ and remote-sensing data of aerosols, trace gases and clouds. Furthermore, Switzerland will contribute to ACTRIS with Atmospheric Simulation Chambers (PSI), as a partner of the Calibration centre for trace gases (CiGAS, Empa), and by providing traceability of aerosol optical depth (AOD) measurements to the WMO primary AOD reference (PMOD).

The national partners/stakeholders are PSI, Empa, MeteoSwiss, ETHZ, PMOD/WRC, University of Bern, and the high-Altitude Research Station Jungfraujoch.

National relevance

Sustained coordination within Europe is indispensable for the future high-quality analysis of atmospheric aerosols, trace gases and clouds. This calls for establishing standardised measurement and quality control protocols to ensure harmonised datasets of high accuracy. Moreover, the ACTRIS data centres play a key role in maximising scientific and societal benefit by making these datasets openly accessible – in machine readable form and near real time – and in establishing routine and online transfer of observational data to other services such as the Copernicus Atmosphere Monitoring Service (CAMS). Only a common approach embedded in the international community allows us to efficiently address future needs and challenges.

Switzerland is well embedded in the European science community for atmospheric aerosols, trace gases and clouds, and the research groups involved are among the world leaders in the analysis of aerosols, aerosol–cloud interactions and trace gases. All Swiss activities (including NABEL) have established strong links to the European research communities and stakeholders (e.g. EMEP, EUMETNET) and global key players, such as the Global Atmosphere Watch (GAW) Program of the World Meteorological Organization (WMO) with its connection with the meteorological science community and MeteoSwiss. Switzerland has been active in several scientific advisory groups of GAW, to which ACTRIS is a critical European contribution.

[71] The total includes the participation fees as well as contributions by PSI, Empa, MeteoSwiss, ETHZ, PMOD/WRC, University of Bern, and the high-Altitude Research Station Jungfraujoch, plus the requested contribution by SERI.

[72] Additional amount requested by the above Institutions for participation in the activities of ACTRIS.

European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER)

Legal form: *eLTER is a pan-European network, based on bylaws accepted by national networks, of LTER international (ILTER) which is based on an international convention*

Main funding sources: *Host states, member states, EU funding from H2020/FP9 INFRA programme*

Funding in Switzerland:

Funding projection	Total CH share[73] (CHF m)	Participation fees[74] (CHF m)
2017–2020	6.36	0.05
2021–2024	6.36	0.05
2025–2028	6.36	0.05

Description

The overall purpose of the eLTER RI (http://www.lter-europe.net/elter-esfri) is to provide a pan-European integrated Research Infrastructure (RI) of long-term research sites for multiple and cross-disciplinary use in the fields of ecosystem, critical zone and socio-ecological research contributing to Global Research Infrastructures such as ILTER and GEOSS. The eLTER RI features a unique "whole system approach" from plot to landscape scale, integrated in a nested design and allowing for interdisciplinary natural science research and investigating human-environment-systems at landscape scales.

The aim is to secure scientific excellence through the highest quality of interoperable services in close interaction with related European and global RIs. This excellence implies both, increased research quality through scientific cross-disciplinary synthesis and quantity in terms of the number of appropriately equipped research sites. The eLTER RI will provide indispensable integrated datasets for system model development and validation, hence supporting system understanding, predictions and decision-making.

Pan-European RI components will seamlessly link the network of up to 25 National Research Infrastructures, comprising approx. 200 sites and multiple user communities of eLTER RI services. The design secures full complementarity with related environmental in-situ RIs such as ICOS, DANUBIUS and AnaEE. Generic services from e-infrastructures (e.g. LifeWatch, EUDAT) will be complemented by cost-efficient elements such as DEIMS (https://deims.org/) to serve continental and global users.

National relevance

With the anticipated consideration for the ESFRI roadmap 2019, LTER Switzerland will be an attractive partner in the European research landscape, and the Swiss research system will greatly benefit from the eLTER–ESFRI network in terms of the following main aspects: (1) Facilitated transnational access to proof-tested categories of approx. 200 in-situ facilities and to harmonised data from long-term observations (including remotely sensed data) of environmental and socio-economic key parameters. (2) The eLTER network provides a high potential at local, national and European scale, for standardisation, common protocols, established standards and basic interfaces with related infrastructures data assembly, from which LTER Switzerland could benefit greatly. (3) Facilitated access to future ESFRI related calls, applying "ecosystem" or "whole-systems" approaches. (4) The participation in eLTER will allow the Swiss research system to apply a comprehensive and integrated view on interactions within natural and human influenced systems. (5) The participation of LTER Switzerland in eLTER will further increase the visibility of the Swiss research system and thus foster international networking and globally competitive research frameworks for cutting-edge science and extend the opportunities to promote the excellent expertise in Swiss forest and ecosystem research and unrivalled research facilities.

[73] The total includes the participation fees and is contributed mainly by the Swiss Federal Research Institute WSL.

[74] The participation fees are paid by WSL, Uni Basel (SLU), Uni Basel (ALPFOR), ETHZ (Grassland Sciences).

Extreme Light Infrastructure (ELI)

Legal form: *ERIC (planned)*
Main funding sources: *Host states, member states, EU structural funds*
Funding in Switzerland:

The way in which Switzerland will participate in ELI has not yet been settled. In a first phase, the ELI Host States could request financial support from Switzerland in view of the ELI operation in the context of the Swiss contribution to the enlarged EU.

Description

The Extreme Light Infrastructure (ELI, https://eli-laser.eu/the-eli-project/) is the first international laser user facility. It is implemented in three pillars located in Central-Eastern Europe and is to be organised in the form of an ELI ERIC. ELI provides access to unique lasers and secondary sources (particles, x-rays) that push the frontier of extreme light-matter interaction science in terms of highest intensities, shortest time scales and broadest spectral coverage.

This infrastructure will be dedicated to multidisciplinary scientific and technical applications. Its capabilities are based on ten different primary laser sources, plus an accelerator-based gamma-beam source, completed with specific user-related instruments. Multiple beamlines allow the use of coherent radiation with unprecedented peak power (>10 PW), intensity (>10^{22} W/cm^2) and temporal resolution (attosecond: 10^{-18} s), as well as laser-accelerated particles for fundamental studies in atomic, molecular, plasma and nuclear physics. This infrastructure is intended for multidisciplinary scientific and technical applications, including but not limited to:

- Basic and applied research in physical, chemical, material and life sciences.
- Strong-field quantum electrodynamics and associated vacuum effects.
- Cutting edge laser technologies related to power, intensity and time-resolution.
- A combination of laser and accelerator technologies to investigate nuclear structure and reactions, as well as nuclear astrophysics with unprecedented precision and accuracy.

Users are expected to come from several scientific fields, ranging from materials science, biology, chemistry and medicine to nuclear physics and laboratory astrophysics. The knowledge and know-how produced will have a large impact on highly advanced technological fields, from optical components to electronics, advanced materials, biomedical equipment, etc.

The implementation of the first three pillars of ELI located in Czech Republic, Hungary and Romania started in 2011 and is to be completed in 2019. It is being funded by a combination of European Regional Development Funds (ERDF) and national contributions from the host countries (totalling ~EUR 850 m). ELI's Operation Phase begins in 2018. The three pillars will be operated, governed and funded by a newly established ELI ERIC, composed of interested member countries. ELI will operate as an international laser user facility, open to access by an international user community, with a Steady-State Operations budget (planned 2023) of approximately EUR 75 million.

National relevance

In its size and scope, ELI complements research infrastructures in Switzerland very well. The lasers are larger, more intense and more powerful than those in any laboratory presently existing or planned at university level in Switzerland. In terms of parameters, ELI also complements the SwissFEL facility at PSI. Switzerland has a strong Ultrafast Science community that can expand the parameters space for its research through access to ELI and thereby maintain its international competitiveness. Lasers and secondary sources will also attract Swiss researchers beyond Ultrafast Science for diverse applications in physics, chemistry, biology and materials science.

Annex B1: Participation in international research infrastructures for consideration

Annex B2: Participation in international research organisations

Foreword

Switzerland is a member of several international research organisations governed by a series of multilateral agreements. The figures in the table below show the impact of the estimated financial requirements for this class of infrastructure on the education and research sector during the periods covered by the 2017–2020 and 2021–2024 ERI Dispatches.

The table was drawn up by SERI in February 2018, taking into account for the period 2017–2020 the payments made in 2017 and the payments planned for 2018–2020, in accordance with the budget approved by Parliament. For the 2021–2024 period, SERI's estimates relate to the payments that Switzerland could be asked to make owing both to existing commitments and to commitments it may need to enter into in the near future (these figures are in *italics and underlined* in the table).

There was no major change to these estimates between February 2018 and the date the Roadmap was published.

Legal basis for funding	**International research organisation (IRO)**	**2017–2020 (CHF m *planned*)**	**2021–2024 (CHF m *estimated*)**
Existing IROs *Dispatches draft budget / ESS / ERI 2013–16*	CERN	181	189
	ESO	38	45.5
	EMBC/EMBL	24	26.5
	ESRF	17	18
	European XFEL	7.5	15.5 [1]
	European Spallation Source ERIC (ESS)	58.5	50 + *32* [2]
	ILL (2014–2018)	6.5	-
	Support measures	12	12
Total		**344.5**	**388.5**
New IROs *ERI Dispatches 2017–20 / CTA*	ILL (2019-2023) [3]	6.5	8.5
	CTA [4]	*2.5*	*10*
Total		344.5 + 9 = **353.5**	388.5 + 21 = **409.5**
New IROs *ERI Dispatch 2021–24*	ILL (2024–2028) [5]		*2.5*
	SKA	-	*9*
	ELI [7]	-	*0* [6]
	LBNF-DUNE	-	*0* [6]
	Requests for special actions from CERN	-	*0* [6]
Total		**353.5**	409.5 + 9 = **418.5**
CH-EU IRO *EU Dispatches 2014–20 / 2021–27*	ITER/Fusion for Energy	78.5	*29* + *110* [8]
Impact on education and research sector		353.5 + 78.5 = **432**	418.5 + 139 = **557.5**

[1] From 2023 onwards, Switzerland's contributions to European XFEL will be linked to Swiss researchers' (intensive) use of the infrastructure in previous years, which will mean an increase in the amounts paid.

[2] *Estimate* of the amount Switzerland may be required to contribute to meet additional costs in the 2021–2024 period.

[3] Switzerland's participation in the IRO is not usually for a set period of time, except in the case of the ILL, where Switzerland has five-year agreements with the institution which must be renewed at the end of their term. This means that each five-year participation in ILL (ILL 2014–2018, ILL 2019–2023, ILL 2024–2028) may be considered from a legal point of view as a separate participation in an IRO. The terms of Switzerland's participation in ILL 2019–2023 were negotiated by SERI in 2018.

[4] because the beginning of construction of CTA was delayed, only CHF 2.5 million is due to be paid in the 2017–2020 period instead of the CHF 8 million earmarked as decided following examination of the 2017–2020 ERI Dispatch.

[5] Switzerland plans to wind down its participation in ILL. However, any decision regarding Switzerland's participation in ILL 2024–2028 and the scope of this will have to take account of the construction delays at the European Spallation Source and also of Swiss researchers' need for access to high-quality neutron sources.

[6] Any contributions Switzerland may make do not affect the ERI budget for the 2021–2024 period. However, SERI envisages that a federal contribution will be made to activities at CERN in support of the LBNF-DUNE infrastructure, which will be funded from monies Switzerland already has with CERN.

[7] A description of ELI can be found in Annex B1 along with other organisations on which the SNSF has already made a statement.

[8] Switzerland has not yet committed to making any financial contributions to the EU for the ITER/Fusion for Energy project beyond 2020. The estimated amounts for the 2021–2024 period include a payment of CHF 29 million already planned and a payment of CHF 110 million to meet additional costs arising from the construction of ITER.

During the current ERI period, Switzerland is considering participation (not necessarily in the form of membership) in the following organisations:

- CTA: Cherenkov Telescope Array
- SKA: Square Kilometre Array
- LBNF-DUNE: Long-Baseline Neutrino Facility/Deep Underground Neutrino Experiments
- ELI[75]: Extreme Light Infrastructure

NB:

1) **The financial figures in this document for the ERI periods 2021–2024 and 2025–2028 are forecasts only and are given as a rough estimate of probable future costs and how they will be allocated.**
2) **Last information update: July 2018**

[75] A description of ELI can be found B1 with the organisations on which the SNSF has already stated its position.

European Organization for Nuclear Research (CERN)

Description

The European Organisation for Nuclear Research (CERN, https://home.cern/) in Geneva, which was founded in 1953, provides the platform for cooperation between European states for exclusively peaceful purposes in the field of nuclear and particle physics and promotes leading research in high-energy physics with its purpose-built particle accelerators and detectors.

The Proton Synchrotron PS and Super Proton Synchrotron SPS are world-class particle accelerators used for research. In 2009, the Large Hadron Collider (LHC) was put into operation. The LHC was built in the same ring tunnel that formerly was used to house the Large Electron-Positron Collider (LEP). By the time it was decommissioned at the end of 2000, the LEP had made a lasting contribution to the scientific knowledge of elementary particles. Since 2006, CERN has broadened its field of activity to include neutrino physics. This has enabled research on CERN-produced neutrinos to be carried out inside large underground detectors at the Gran Sasso Laboratory in Italy.

The 22 member states of CERN are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland, Slovakia, Spain, and the United Kingdom.

CERN is located on the Swiss-French border near Geneva and employs approximately 2,500 people on a permanent basis, who together with about 12,000 visiting researchers per year from all around the world advance scientific knowledge in the field of nuclear and particle physics. In the some 60 years of its existence CERN has been a leading force in all the major discoveries concerning the composition of matter. It conducts research into the question both of the origin and nature of the basic building blocks of matter and the forces that hold them together. In 2013, the discovery of the Higgs particle at CERN was recognised with the Nobel Prize for physics.

National relevance

Swiss researchers from 12 institutes representing all universities are active in CERN experiments, primarily in the fields of particle physics (high energetic collisions, neutrinos, astroparticles, matter/antimatter), medicine and technological research (electronics, materials). Great importance is also attached to technology transfers to Swiss industry. Swiss universities are heavily involved in the development and expansion of the CERN infrastructure, including the construction of the large detectors ATLAS, CMS and LHCb for the LHC. This has called for an important financial and scientific commitment, particularly from the universities of Basel, Bern, Geneva, Lausanne and Zurich as well as the federal institutes of technology in Zurich and Lausanne. The latter (EPFL) is also involved in the luminosity upgrade of the LHC (HL-LHC) that will be commissioned by 2026. In 2018, the Paul Scherrer Institute, the University of Geneva and the ETH Zurich and EPF Lausanne signed a collaboration agreement with CERN for R&D work mainly in the field of high-field superconducting magnet design and circular collider design in view of a Future Circular Collider (FCC). Depending on the European Strategy for Particle Physics, to be updated by 2020, the FCC could be the next big accelerator built at CERN.

CERN employs around 200 Swiss researchers, engineers, technicians and business people, trainees and students at its facilities. CERN is also an attractive economic partner for Switzerland: more than three times the amount of Switzerland's annual contribution to CERN is recouped in the form of contracts for the Swiss industrial and services sectors.

Switzerland finances around 4% of CERN's annual overall budget. Responsibility for Switzerland's contribution to CERN rests with SERI.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ CHF 4500 m	Swiss Confederation: ~ CHF 181 m	~ CHF 4600 m	Swiss Confederation: ~ CHF 189 m	~ CHF 4700 m	Swiss Confederation: ~ CHF 200 m

* The Swiss part of the global funding constitutes its membership contributions.

European Southern Observatory (ESO)

Description

ESO, the European Southern Observatory (https://www.eso.org), is the foremost intergovernmental astronomy organisation in Europe and the world's most productive astronomical observatory. ESO provides state-of-the-art research facilities to astronomers.

The 16 member states of ESO are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, Ireland, the Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Several other countries have expressed an interest in membership. Australia has concluded a partnership agreement with ESO, while Chile acts as the host state of ESO.

ESO's main mission, laid down in the 1962 Convention, is to provide state-of-the-art research facilities to astronomers and astrophysicists, allowing them to conduct front-line science in the best conditions. ESO employs around 700 staff members. By building and operating a suite of the world's most powerful ground-based astronomical telescopes enabling important scientific discoveries, ESO offers numerous possibilities for technology spin-off and transfer, together with high technology contract opportunities.

The ESO Headquarters (comprising the scientific, technical and administrative centre of the organisation) are located in Garching near Munich, Germany. In Chile, ESO operates the Santiago Centre as well as three unique observing sites: La Silla, Paranal and Chajnantor. At the La Silla Paranal Observatory in Chile, ESO operates an array of the world's most advanced telescopes, including the Very Large Telescope (VLT). Furthermore, ESO represents its members within the international Atacama Large Millimetre Array (ALMA) project - a network of 64 radio telescopes, each with a diameter of 7–12 metres, located on the Chajnantor Plateau at an altitude of 5,100 m. ALMA was inaugurated as a partnership with North America and Japan in 2013, although the first scientific observations had already begun in 2011 using part of the facility.

Since 2005 ESO has been working with its community and industry to develop an extremely large optical/infrared telescope. Dubbed ELT for Extremely Large Telescope, this revolutionary new ground-based telescope concept will have a 39-metre main mirror and will be the largest optical/near-infrared telescope in the world. The ELT programme was approved in 2012 and green light for construction was given at the end of 2014. First light is targeted for 2025.

National relevance

ESO telescopes provide the data for many results and breakthroughs in astronomy, and lead to a large number of scientific publications each year. Astronomers use these state-of-the-art observatories to study objects from within our solar system to the farthest reaches of the Universe.

With two scientific papers being published every day, the ESO Observatories are in fact the most productive ground-based astronomical facilities in the world.

Swiss membership in ESO provides Swiss astronomy researchers with access to the entire ESO infrastructure.

Thanks to the outstanding quality of the Swiss astronomy institutes (Bern, Geneva, Lausanne and Zurich), which are able to make the most of Swiss participation in ESO (and ESA in the field of space astronomy), Swiss astrophysics research enjoys a strong international reputation.

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ EUR 862 m	Swiss Confederation: ~ CHF 38 m	~ EUR 950 m	Swiss Confederation: ~ CHF 45.5 m	~ EUR 1000 m	Swiss Confederation: ~ CHF 50 m

* Membership contribution and contributions to ELT (Extremely Large Telescope).

European Synchrotron Radiation Facility (ESRF)

Description

The ESRF (https://www.esrf.eu/) is one of the world's largest synchrotron science centres. Every year, 7,000 scientists from 22 partner countries and from around the world travel to Grenoble to use the ESRF's extremely brilliant X-rays for leading-edge research activities. The ESRF operates 44 beamlines exploiting the full range of X-ray-related experimental techniques and provides its users with a large scope of services. Since 2017, the organisation gas also operated a high-end cryoelectron microscope.

The 13 state parties to the ESRF Convention are France, Germany, Italy, United Kingdom, Russia, Belgium, the Netherlands, Denmark, Finland, Norway, Sweden, Spain and Switzerland. In addition, Austria, Israel, Czech Republic, Hungary, Poland, Portugal, India and South Africa have concluded time-limited partnerships with the ESRF.

ESRF scientific output includes more than 1,800 scientific publications per year, of which more than 300 in high-impact journals, ranging over a broad spectrum of research areas, such as hard and soft condensed matter science, applied material science, chemistry, structural biology, medicine, Earth and environmental sciences, and cultural heritage. Moreover, the ESRF conducts its own research on synchrotron physics, synchrotron methods and instrumentations, and soft matter structure.

The ESRF has been in operation since 1992. After 20 years of success and scientific excellence, the ESRF, the world's first third-generation light source, has embarked upon an ambitious and innovative modernisation project – the Upgrade Programme, which aims at maintaining ESRF's world-leading role through a continuous quest for higher performance figures, meeting the needs of returning users, and attracting scientists from new disciplines. After the successful delivery of the first phase of this programme in the period 2009–2015, in May 2015 the ESRF launched the ESRF – Extremely Brilliant Source (ESRF-EBS) project. The ESRF-EBS project was highlighted as an ESFRI landmark in the 2016 ESFRI roadmap.

ESRF-EBS involves an investment of EUR 150 million over the 2015–2022 period. The principal aim of this project is to construct and commission the new 844m circumference ESRF-EBS storage ring. About 90% of the existing infrastructure will be re-used, and the new ESRF-EBS design has been conceived with greatly improved energy efficiency, reducing electricity costs by 20%. With performances multiplied by 100 in terms of brilliance and coherence, this new source of synchrotron radiation will offer unprecedented tools for the exploration of matter and for the understanding of life at the macromolecular level.

National relevance

The ESRF is a leading world-class synchrotron radiation facility providing unique beam characteristics and instruments. Swiss researchers from over 20 institutes and research centres use about 4% of the ESRF available beamtime for their investigations and experiments. The extensive use of the ESRF by Swiss researchers demonstrates how access to this facility complements the availability of the Swiss Light Source (SLS) at the Paul Scherrer Institute (PSI).

Synergies between ESRF and SLS will be leveraged as the ESRF undergoes in 2019 and 2020 a 21-month shutdown for the EBS upgrade, as well as a shutdown of the SLS due to the coming implementation of the upgrade SLS 2.0.

During the construction, operation and upgrade of the ESRF, Swiss industry delivered several high-technology components and systems to the site in Grenoble. Between January 2015 and September 2018, the value of contracts going to Swiss industry for operations, maintenance and upgrades at the ESRF was around 51% of the contribution that Switzerland makes to the ESRF's total budget (three year average). Switzerland is one of the ESRF members with the highest industrial return. This return is expected to significantly increase in 2019 in the context of the procurement of X-rays detectors for EBS-upgrade.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss**
~ EUR 340 m	Swiss Confederation: ~ CHF 17 m	~ EUR 370 m	Swiss Confederation: ~ CHF 18 m	~ EUR 400 m	Swiss Confederation: ~ CHF 20 m

* Membership contributions and contributions to EBS upgrade programme.
** Membership contributions

Development phases

Design	Preparation	Implementation	Operation
1977–1987	1987–1989	1988–1992	1992–

Institut Laue-Langevin (ILL)

Description

Since its inception in 1967, the Institut Laue-Langevin (ILL, https://www.ill.eu/) has sought to become the most reliable neutron source for research and studies in the fields of material sciences, solid-state physics, chemistry, crystallography, molecular biology as well as nuclear and fundamental physics.

Owing to its high-flux reactor, which became operational in 1971, ILL operates one of the most intense neutron sources in the world, feeding some 40 experimental stations. Thanks to its outstanding infrastructure, the ILL has positioned itself at the forefront of neutron research. Every year several hundred scientists carry out their experiments and measurements at this unique research facility in Grenoble.

The three states that are parties to the ILL protocol are France, Germany and the United Kingdom. Italy, Spain, Switzerland, Poland Austria, the Czech Republic, Hungary, Slovakia, Belgium, Denmark and Sweden have concluded time-limited partnerships with ILL.

With a total staff of almost 500, ILL's operating costs reach approximately EUR 90 million a year. Since ILL is a nuclear facility it is obliged to comply with heightened security requirements since the Fukushima accident in an industrial environment that has become generally difficult. Operating the facility has therefore become tougher but the fundamental importance of the services it supplies for research throughout the world amply justify the efforts of its members and associates.

In order to ensure its leading position in world neutron science and further increase the performance of its infrastructure, ILL has been going through an upgrade process since 2001. This is being carried out in two phases. The first, Millennium, which was completed in 2015, involved the installation of 14 new or completely overhauled instruments, including replacement of the neutron sources, enabling the multiplication of the rate of detection by a factor of 24. The second phase, Endurance, began in 2015 and is being carried out in stages, and involves the installation of seven new instruments and the updating of four existing ones.

National relevance

Switzerland's scientific partnership in ILL is based on a time-limited partnership agreement signed in 1988 which was extended by five years in 1993, 1998, 2004, 2008 and 2014. Switzerland is thus participating for a seventh five-year period (2019–2023) in this institute at the leading edge of world research into neutron diffusion. Its annual contribution in 2019 is CHF 3.2 million, representing 2.4% of ILL's budget, which determines the rate of utilisation of the facility for Swiss researchers. The State Secretariat for Education, Research and Innovation (SERI) is responsible for Switzerland's participation in ILL. The use and maintenance of ILL infrastructure creates substantial orders for Swiss industry. The Swiss Industry Liaison Office is responsible for promoting relations between Swiss companies and ILL.

See also the page on European Spallation Source ERIC (ESS) in Annex B2 for more information on neutron sources.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ EUR 390 m	Swiss Confederation: ~ CHF 13 m	~ EUR 400 m	Swiss Confederation: ~ CHF 8.5 m	~ EUR 410 m	Swiss Confederation: ~ CHF 2.5 m

* Scientific membership contributions (see also table at the beginning of Annex B2).

European X-Ray Free Electron Laser (European XFEL)

Description

In the 3.4 km long tunnels of European XFEL (https://www.xfel.eu), extremely intense X-ray flashes are generated. With its special characteristics of ultrashort pulses and ultrahigh brilliance, the European XFEL offers completely new opportunities in many areas of research. The relevant Swiss partners and stakeholders are correspondingly diverse. They come from public funded research (e.g. PSI) as well as from industry (e.g. pharma).

The 11 states that are parties to the European XFEL Convention are France, Germany, Italy, United Kingdom, Russia, Denmark, Poland, Sweden, Slovakia, Hungary and Switzerland.

The goal of the RI is to offer new opportunities to top researchers from many areas and to enable excellent and cutting edge research experiments.

The RI was inaugurated in September 2017. Initially, only one beamline feeding two instruments (SPB/SFX and FXE) was functional. In 2018, an additional beamline feeding two instruments (SCS and SQS) has opened. In 2019, a third beamline feeding two additional instruments (HED and MID) will become functional.

National relevance

Besides the purely scientific interest (covering many fields: physics, structural biology, material sciences, etc.), European XFEL is very relevant for Switzerland because of its complementarity with SwissFEL, another free electron laser that was recently built at the Paul Scherrer Institute. During the planning and construction phase, SwissFEL has greatly profited from the expertise of European XFEL and vice versa. There is ongoing exchange between the two infrastructures.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss**	Global	Swiss**
~ EUR 542 m	Swiss Confederation: ~ CHF 7.5 m	~ EUR 600 m	Swiss Confederation: ~ CHF 15.5 m	~ EUR 650 m	Swiss Confederation: ~ CHF 11 m

* Construction and operation
** Operation

Development phases

Design	Preparation	Implementation	Operation
Before 2005	2005–2009	2009–2019	2017–

European Spallation Source ERIC (ESS)

Description

The European Spallation Source ERIC (ESS, https://europeanspallationsource.se/) in Lund (Sweden) is a research facility under construction that will produce long pulses of neutron radiation with very high intensity. In contrast to X-rays normally used in materials research, neutrons do not interact with the layer of electrons of the atoms of the materials under investigation. For this reason it enables research into the structure and dynamics of materials at the molecular and atomic scale that is not possible with X-rays.

ESS will be the most powerful source of neutrons in the world and as such will offer unique opportunities for cutting-edge research into both applied and basic fields of research. Whether the aim is to probe the molecular composition of the materials of archaeological artefacts or of metal construction parts, analyse biomolecular processes, understand the electronic structure and dynamics of new superconductors, or identify the basic causes of parity violation in elementary particle physics, ESS will allow new discoveries and technological progress to be made in these and other fields of research.

The 13 states that are members of European Spallation Source ERIC are France, Germany, Italy, United Kingdom, Denmark, Sweden, Norway, Estonia, Hungary, Poland, Czech Republic, Spain and Switzerland. Construction of the facility began at the beginning of 2014. The costs of construction and operations of ESS until 2026 are expected to amount to some EUR 2.74 billion, of which EUR 1.83 billion will be spent on building (at 2013 prices). Operations are due to start in 2019 and be in full operation as from 2026 with annual costs of approximately EUR 140 million.

In contrast to the traditional sources of neutrons, the neutrons at ESS are not produced through splitting atoms in a reactor, but through firing metal (Wolfram) with protons ('spallation'). Both in terms of the new technology and performance data, ESS enters new territory and will become by far the most powerful source of neutrons in the world.

Neutron sources are already in operation in the US, including HFIR (reactor) and SNS (spallation), in Japan with JPARC (spallation), Germany, with e.g. FRM II and BER II (reactors), France with ILL (reactor) as well as Switzerland with SINQ (spallation). Owing to its higher performance by several orders of magnitude, ESS will complement these facilities: the newly accessible research fields accessible through ESS cannot be processed at the existing neutron source facilities.

National relevance

Switzerland has been involved in the planning of ESS and the construction work from the outset and will continue to play an active part in its operation. With the federal decree of 20 March 2015 on Switzerland's participation in ESS-ERIC, the Federal Assembly approved a total of CHF 130 million until 2026, corresponding to approximately 3.5% of construction and operation costs. Swiss researchers and institutions, such as the PSI and EPFL, have already been prominent in the ESS planning phase and will continue to be actively involved in the future.

Switzerland's involvement in ESS complements the investments in existing neutron source facilities both at the national level (SINQ) and international level (ILL), as a result of which Swiss researchers are ensured the best possible access to such leading research centres.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ EUR 1200 m	Swiss Confederation: ~ CHF 58.5 m	~ EUR 700 m	Swiss Confederation: ~ CHF 82 m	~ EUR 600 m	Swiss Confederation: ~ CHF 30 m

* Membership contributions

Development phases

Design	Preparation	Implementation	Operation
Up to 2011	2011–2015	2015–2026	2023–

European Molecular Biology Laboratory (EMBL)

Description

EMBL (https://www.embl.de) was set up in 1974 in order to promote molecular biology across Europe, and to create a centre of excellence for Europe's leading young molecular biologists. To accomplish this, EMBL has pursued five major missions:

- Basic research in molecular biology: Through its past and current Scientific Programmes, EMBL has developed an integrative, interdisciplinary structure that is ideally suited to tackling the challenge that lies ahead for the Life Sciences: understanding complex biological systems.

- Technology and instrumentations: Instrument and technology development have a long history at EMBL. Some of the first experiments carried out in the Laboratory involved the adaptation of radiation from a synchrotron source for use with biological material. Other areas of instrument development include DNA sequencing, cell fractionation, light and electron microscopy methods, mass spectrometry of proteins, X-ray imaging plates, synchrotron beamlines and automated cell micro injectors.

- Facilities and services: EMBL provides various biological databases run by the European Bioinformatics Institute in Hinxton, UK. Millions of users consult these databases each year, seeking information on DNA sequences, protein structures, gene expression profiles, human genetic polymorphism or comparative analyses of entire genomes. At two of its sites, Hamburg and Grenoble, EMBL provides access to world-leading sources of X-ray and neutron radiation. EMBL's Advanced Light Microscopy Facility (ALMF) in Heidelberg is the centre of a series of national nodes throughout Europe that allow real time imaging of molecular and cellular events. Other, smaller facilities include mass spectrometers, microarray systems, electron microscopes, DNA sequencing and protein production instruments.

- Teaching and training: The multifaceted training programme of EMBL is world-renowned and makes the Laboratory a true meeting place for biologists in Europe. In addition EMBL, often in collaboration with its sister organisation EMBC, organises multiple training courses, workshops and symposia every year for life scientists and wider audiences.

- Technology transfer: EMBL is actively engaged in developing its discoveries to benefit society. EMBL Enterprise Management Technology Transfer GmbH (EMBLEM, established in 1999) is an affiliate and the commercial arm of the European Molecular Biology Laboratory. EMBLEM facilitates and accelerates the transfer of innovative technology from basic research to industry (spanning the pharmaceutical, biotech, ITC and mechanical/electrical engineering markets).

The 25 member states of EMBL are Austria, Belgium, the Czech Republic, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Island, Israel, Italy, Ireland, Luxembourg, Malta, Montenegro, the Netherlands, Norway, Portugal, Spain, Slovakia, Sweden, Switzerland and the United Kingdom. Australia and Argentina have concluded an association agreement with EMBL.

National partners/stakeholders: all Swiss universities and institutions active in the field of the organisation, young researchers interested in working work at EMBL.

National relevance

EMBL is a unique and powerful hub for R&D in continental Europe from which the latest research and technologies can dissipate with unmatched efficiency to the Swiss life science and medical research communities. Notably, this efficiency depends also on the proactive networking behaviour of researchers in Switzerland.

Funding (including Swiss participation in EMBL's sister organisation EMBC)

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ EUR 450 m	Swiss Confederation: ~ CHF 24 m	~ EUR 500 m	Swiss Confederation: ~ CHF 26.5 m	~ EUR 550 m	Swiss Confederation: ~ CHF 34 m

* Membership contributions

European Life Science Infrastructure for Biological Information (ELIXIR)

Description

The goal of ELIXIR (https://www.elixir-europe.org) is to coordinate resources such as databases, software tools, training materials, cloud storage, and supercomputers so that they form a single infrastructure. This infrastructure, funded in 2014, makes it easier for scientists to find and share data, exchange expertise, and agree on best practices. Ultimately, it will help them gain new insights into how living organisms work.

ELIXIR's Compute Platform is creating a network of supercomputer services that is making it easier for researchers to manage the huge increase in life science data. It enables researchers across Europe to use existing facilities to store, transfer and analyse large datasets. The Data Platform is establishing quality criteria and markers for datasets. ELIXIR can deal with the increasing complexity of data that exists in a wide range of formats and descriptions. ELIXIR's Interoperability Platform is finding ways to standardise data saving and description and the Training Platform is running courses on dealing with large and complex datasets.

ELIXIR is needed to build a more robust bioinformatics infrastructure. Bioinformatics is a discipline that uses computer programs to gain insights from large datasets, particularly data from gene sequencers. ELIXIR promotes an exchange of knowledge and support around Europe so that smaller bioinformatics resources can grow and join a pan-European infrastructure. This makes new datasets available to researchers across Europe.

Handling and analysing the massive amounts of data now generated in the life sciences often takes more resources than agri-business and biotech firms have. One solution is to collaborate with public services like ELIXIR. ELIXIR runs an industry programme that promotes these collaborations across the globe. It will stimulate innovations in biotechnology and pharmaceutical industries, as well as in agricultural and environmental research.

The 22 members of ELIXIR are Belgium, the Czech Republic, Denmark, EMBL[76], Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Slovenia, Sweden, Switzerland and the United Kingdom.

National partners/stakeholders are organised within the National Node coordinated by SIB.

National relevance

ELIXIR provides the national and international life science community with a state-of-the-art bioinformatics infrastructure, including resources, expertise and services.

ELIXIR federates world-class researchers and delivers training in bioinformatics.

SIB as the national node plays an important role nationally and internationally.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~ EUR 26 m (hub budget)	Swiss Confederation: ~ CHF 1.1 m (contribution to hub)	~ EUR 30 m (hub budget)	Swiss Confederation: ~ CHF 1.5 m (contribution to hub)	~ EUR 33 m (hub budget)	Swiss Confederation: ~ CHF 1.7 m (contribution to hub)

* Contribution towards the ELIXIR Hub in the UK

Development phases

Design	Preparation	Implementation	Operation
2007–2010	2011–2013	2014–2018	From 2019

[76] European Molecular Biology Laboratory.

International Experimental Fusion Reactor (ITER)

Description

ITER (https://www.iter.org/) is a cooperation project launched through an international treaty signed in in 2006 to build the ITER fusion reactor in Cadarache (France). ITER is expected to facilitate the final developmental step from experimental nuclear fusion to the delivery of fusion electricity to the grid. Being the largest tokamak ever built and employing superconducting technologies for magnetic confinement, ITER has the following goals:

1) To produce 500MW of fusion power out of 50MW of input heating power, reaching a tenfold return on energy (Q=10).

2) To demonstrate the integrated operation of technologies for a fusion power plant, bridging the gap between today's smaller-scale experimental fusion devices and the demonstration fusion power plants of the future.

3) To achieve a deuterium-tritium plasma in which the reaction is primarily sustained through internal heating, i.e. to sustain a 'burning plasma'.

4) To test methodologies to produce inside the vacuum vessel the tritium that is required by the fusion reaction and test mock-up in-vessel tritium breeding blankets.

5) To demonstrate the safety characteristics of a fusion device.

According to the new baseline, adopted ad referendum by the ITER members in 2016, the most important milestones of ITER are i) producing the first non-nuclear plasma in 2025 and ii) the start of decisive nuclear deuterium-tritium experiments in 2035.

The ITER Organization (IO) is the international organisation responsible of the construction, operation, de-activation and dismantling of the ITER fusion reactor. Its members are China, India, Japan, South Korea, USA and the EU. Each member bears 9% of the ITER costs, except for the EU, which bears 45% as ITER Host Party. Each member set up a domestic agency dedicated to the delivery of its contribution to ITER.

Based in Barcelona, Fusion for Energy (F4E) is the EU domestic agency responsible for the delivery of the European contribution to ITER. Established in 2007, the European Joint Undertaking for ITER and the Development of Fusion Energy, known as Fusion for Energy (F4E), is the EU domestic agency responsible for the preparation and the delivery of the EU contribution to ITER. It is also responsible for the EU contribution to the Broader Approach, a collaboration with Japan aiming at complementing the ITER project and accelerating the realisation of fusion energy through R&D and advanced technologies for future demonstration fusion power reactors (DEMO).

F4E members are Euratom (represented by the European Commission), the 28 EU member states and Switzerland. Switzerland thus participates in the construction of ITER via F4E. Switzerland is represented by the EU in the governance of IO, as are all the EU member states.

National relevance

The realisation of ITER is currently the worldwide cornerstone of fusion research, combining all efforts to assemble the worldwide flagship tokamak. Several other fusion devices contribute to ITER preparation and are intended to complement its results to tackle the next steps toward industrial fusion energy. This includes several tokamaks (JET, JT-60 SA, MAST, AUG, TCV), a stellarator (W7-X), an experimental reactor (JHR), and fusion materials irradiation test facilities (IFMIF-EVEDA and IFMIF-DONES).

European fusion research activities are also focused on ITER, both through F4E activities and the implementation of the European Fusion Electricity Roadmap as part of the Euratom fusion research programme. Swiss academic institutions that are active in fusion research are themselves strongly aligned to international multilateral research collaborations instruments. IO, F4E and the Euratom fusion research programme currently play a central role for Swiss fusion research and will continue doing so for several decades.

Conversely, Swiss fusion research institutions provide specific and worldly recognised high-end competence. The Swiss national competence centre for fusion research, the Swiss Plasma Center (SPC) based at the EPFL, operates one of the three most important medium-sized tokamaks in Europe, the so-called TCV.[77] This device is key to fusion research to study plasma geometry, which is of primary relevance to ITER. The SPC is involved in many activities, including the design of ITER heating systems and the testing of all ITER superconducting cables using its SULTAN device at the Paul Scherrer Institute. The University of Basel is collaborating with F4E and IO to study plasma wall interaction in fusion devices. The Swiss high-tech industry is also involved in F4E and IO activities. Swiss companies design, produce and deliver numerous components of ITER, such as high voltage power supply units, vacuum elements and cryogenic installations, as well as providing a range of services.

The participation of Swiss private and public institutions in the construction of ITER generates considerable industrial return. Between 2007 and 2017 the estimated industrial return reached CHF 135 million, i.e. 85% of the CHF 159 million Switzerland has invested so far in ITER.

Funding

2017–2020		2021–2024		2025–2028	
Global	Swiss*	Global	Swiss**	Global	Swiss**
EUR 2561 m	Swiss Confederation: CHF 78.5 m	EUR 4524 m	Swiss Confederation: CHF 139 m	EUR 3415 m	Swiss Confederation: CHF 104.7 m

* Membership contributions to F4E Joint Fund and contributions via Euratom.
** Membership contributions to F4E Joint Fund and further contributions to be renegotiated.

Development phases

Design	Preparation	Implementation	Operation
N/A	N/A	2007–2025	2026–2037

[77] For more details see the description of the Swiss Plasma Center (SPC) in Annex A2.

Cherenkov Telescope Array (CTA)

Description

The CTA Observatory (http://cta-observatory.org) will be the ultimate generation of high-energy gamma-ray observatory. Up to 118 dedicated Cherenkov telescopes of three different sizes will be deployed on two sites: one on the ESO site of Paranal (Chile) and one on the Island of La Palma (Spain). CTA will be run as a European Research Infrastructure Consortium (ERIC) with its headquarters in Bologna (Italy) and a Science Data Management Center (SDMC) in Zeuthen (Germany). The Key Science Cases will be exploited by a consortium of more than 200 research institutions in 31 countries with about 1,420 members. The data, which will be distributed by the SDMC, will be open-access and scientists will be able to request observation time through a competitive time allocation process.

Building up the full array should cost about EUR 400 million, but future member states of CTAO ERIC have agreed to start with the construction as soon as a threshold of EUR 250 million is secured. This step should be reached in 2019. Full operation should be achieved by 2025. Contributions to the construction of CTA will largely be in kind, allowing research institutions to get involved in the conception of instrumentation and delivering benefits to industry among member states. It is planned to operate CTA for at least 30 years. CTA represents also a computing challenge: the total volume of data to be managed by the observatory archive will be of the order of 25 PB per year.

Images of gamma-ray sources will be reconstructed from the collection of many shower events on the camera planes of the CTA telescopes. Atmospheric showers are the result of the interactions of gamma-rays from sources in the atmosphere. To detect these, CTA exploits an Imaging Atmospheric Cherenkov Technique (IACT), turning the Earth's atmosphere into a detector. With these tools, CTA aims to detect high-energy gamma-rays between about 20 GeV to 300 TeV from cosmic sources. It will be sensitive to the most powerful accelerators in the universe up to distances exceeding by far the limits of our galaxy. CTA aims notably at understanding how black holes and pulsars function. CTA will be at the centre of multi-wavelength and multi-messenger programs with observatories in other electromagnetic bands and using gravitational waves and high-energy neutrinos. For these reasons, CTA has the unique potential to offer a fertile ground of collaboration to the particle physics and the astrophysics communities around the world. It will also offer to the growing astroparticle physics community a proper global intergovernmental research organisation of structure and stability comparable to CERN or ESO.

CTA is highlighted as a priority in the European Astroparticle Physics Strategy 2017–2026 of APPEC (http://www.appec.org/roadmap). It is also acknowledged as an ESFRI Landmark in the 2018 update of the European Strategy Forum of Research Infrastructures (ESFRI) Roadmap.

National relevance

The activity around CTA in Switzerland is currently mainly driven by particle physicists. For instance, Prof. Straumann (University of Zurich) was managing director of the precursor international company CTA GmbH from 2016 till 2017 and Prof. Montaruli (University of Geneva) has been coordinating the development of one of the proposed CTA telescopes, the so called single-mirror SST-1M. Prof. Biland (ETHZ) has also taken part in multiple panels to review CTA and has been operating a demonstrator, called FACT, for the new sensor technology employed by all SST prototypes, the Silicon PhotoMultipliers (SiPMs). Dr Walter's group (University of Geneva) covers coordinating positions in the software control of telescope and data working packages. CTA, as a precursor of the Big Data in Astronomy, may pave the way to bigger challenges such as Square Kilometre Array (SKA), thereby complementing the work of the Swiss National Supercomputing Centre in Geneva (CDCI)[78].

The scientific relevance of CTA for Switzerland and the world is enormous in the data frame and analysis techniques, including machine learning and modern imaging techniques, and in forming contacts with specialised industries which could participate in the construction of telescopes. In the near future, Swiss institutions involved in CTA will be heavily involved in the construction and testing of telescope elements, and will seek to cooperate with local industry.

[78] For more details see the description of the Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI) in Annex A2

A funding line of CHF 8 million has been reserved in the ERI Dispatch 2017–2020 so as to pave the way towards the accession of Switzerland to the CTAO ERIC. It has not yet been decided how funds will be distributed. SERI is participating in ongoing negotiations regarding the establishment of the CTAO ERIC with the other anticipated member states and organisations (DE, FR, IT, UK, SL, CZ, PL, ES, JP, TH, ESO).

Development phases

Design	Preparation	Implementation	Operation
2012–2016	2017–2020	2021–2024	2025–2028 ff

Square Kilometer Array (SKA)

Description

The SKA (https://www.skatelescope.org/) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development when it comes to the observation of the Universe at radio-wavelength (from centimetres to metres). The SKA will eventually use thousands of dishes (in South Africa and nearby countries) and up to a million low-frequency antennae (in Western Australia). It will be run as an intergovernmental research organisation with its headquarters at Jodrell Bank, close to Manchester (UK).

Building up the full SKA should cost several billion euros. However, the SKA will be built in two main phases. The first phase (SKA1) will involve testing the full system in a proof of concept. For SKA1, Australia will host the low-frequency instrument with more than 500 stations, each containing 256 individual antennas, whilst South Africa will host an array of some 200 dishes, incorporating the 64-dish MeerKAT precursor array (in operation since July 2018). The cost of SKA1 has been capped at EUR 650 million in 2013 value. Its construction should start in mid-2020 and its full operation should not be reached until 2025. The second phase (SKA2) is still under discussion. It will complete the telescope arrays at both sites so that SKA can operate some 2,000 high- and mid-frequency dishes and aperture arrays and a million low-frequency antennae. Already SKA1 will be a huge 'big-data' challenge: the total volume to be managed by the observatory archive will be of the order of 300 PB per year. Very high-performance central supercomputers capable of more than 100 petaflops of raw processing power will be required, stretching technology to its absolute limits.

SKA will enable astronomers to monitor the sky with unprecedented sensitivity (10x to 100x more sensitive than current facilities) and survey the entire sky much faster (100x to 10,000x) than any observatory currently in existence. Its unique configuration will give the SKA unrivalled scope in observations, largely exceeding the image resolution quality of the Hubble Space Telescope, but at radio-wavelength. SKA will also offer to the growing radio-astronomy community a proper global intergovernmental research organisation of structure and stability comparable to CERN or ESO.

SKA is acknowledged as an ESFRI Landmark since the 2016 update of the European Strategy Forum of Research Infrastructures (ESFRI) Roadmap. On 12 March 2019, representatives of UK, ZA, AU, IT, NL and PT signed the treaty that aims at establishing SKA as an intergovernmental organisation. Ratification of the treaty by at least five signatories is required for this to take place.

National relevance

Radio-Astronomy in Switzerland has existed for a number of decades, through observations conducted at the Bleien Radio Observatory. Since its beginnings in 1979, the radio observations mainly focused on the observation of solar flares. A growing number of Swiss astrophysicists and cosmologists are now very active in radio-astronomy. They are using the ALMA millimetre radio-interferometer in the context of Swiss membership of ESO and are also collaborating with other scientists involved in various precursors of SKA. However, the Swiss interest in SKA extends far beyond the fundamental questions of astrophysics, as SKA addresses many engineering challenges for which Switzerland has developed internationally renowned expertise, for instance in reliable and precise atomic clocks and timing transport technologies which reside at the heart of SKA. With the Swiss National Supercomputer Center in Lugano, Switzerland has leading worldwide expertise in high-performance computing and could efficiently participate in the SKA 'big-data' challenge. A joint EPFL-IBM Research Zurich initiative on alternative algorithms useful to SKA started five years ago and is about to publish their findings.

In the 2015 Roadmap, the SKA has been identified as an important large research infrastructure for which the participation of Switzerland is to be considered. Since 2016, SERI has attended the meetings of the SKA Board of Directors as observer. The ETH Board would like to see a funding line dedicated to SKA in an ERI dispatch. The allocation of funding has not yet been decided. Also since 2016, the Swiss SKA community with the support of EPFL has organised annual Swiss SKA Days (ska.epfl.ch), at which a number of Swiss industries and start-ups have shown strong interest in the SKA project.

Development phases

Design	Preparation	Implementation	Operation
2012–2019	2019–2020	2020–2027	2020–2035ff

Neutrino experimental facilities in the US and Japan

Description

Two accelerators in the US (at the Fermi National Accelerator Laboratory – Fermilab, near Chicago) and in Japan (at the Japan Proton Accelerator Research Complex – J-PARC, Tokai) produce neutrino beams for scientific purposes. Both facilities already operate several experiments involving Swiss groups and are foreseen to host large complementary projects with international participation. Complementarity experiments using different techniques provide important cross-checks that add credibility to the results of the measurements. These facilities are designed to answer most fundamental questions about the nature of elementary particles and fundamental forces and their role in the universe. We mention, for example, the long-standing issue of the observed supremacy of matter over antimatter, one of the fundamental questions in particle physics and cosmology.

LBNF/DUNE

The Long-Baseline Neutrino Facility (LBNF, https://lbnf.fnal.gov/) together with the Deep Underground Neutrino Experiment (DUNE) in the USA, will be a world-class multipurpose observatory for neutrinos of beam and astrophysical origin and for matter instability searches. LBNF/DUNE is among the top priorities in scientific and infrastructure roadmaps in Europe and the Americas and is attracting growing interest from Asia.

Two complexes will be built, with a 'near' site facility at Fermilab and a 'far' site at the Sanford Underground Research Facility (SURF). The world's most intense beam of neutrinos will be produced at Fermilab and aimed at the SURF site at a distance of 1,300 km from Fermilab. The design of the LBNF/DUNE facilities and detectors are driven by the primary scientific goals of carrying out a comprehensive programme of neutrino oscillation measurements, besides also significantly improving the search sensitivity for proton decays, detecting and measuring neutrinos from core-collapse supernovae and being prepared for unexpected discoveries. One main goal is to reach sensitivity to measure charge-parity symmetry violation (CPV) in neutrino oscillations, which would give insight into the origin of the mentioned matter-antimatter asymmetry.

The detectors at the far and near site will be built by the DUNE collaboration and will be based on volumes of liquefied argon equipped with time-projection chambers, an advanced type of neutrino detector. Two large-scale prototypes are being tested in particle beams at CERN; one of the two detector technology solutions for the far-site detector has been pioneered by ETHZ; and the University of Bern has designed the near detector. Extensive R&D is being conducted in the preparation of the analysis of the data and theoretical studies at ETHZ, Uni Bern and Uni Basel. A. Rubbia (ETHZ) was the first spokesperson of the DUNE collaboration and A. Ereditato (Uni Bern) was a member of the International Governance steering board.

LBNF/DUNE is a global organisation with currently 1,100 scientists and engineers from 175 institutes in 31 countries, with 3% of the members from Switzerland.

The main excavation at the far site in South Dakota has started and the beginning of beam operation is planned for 2026 and will last for at least 10 years. The total construction cost of LBNF/DUNE is estimated at around USD 2,500 million.

HyperK

Hyper Kamiokande (HyperK, http://www.hyperk.org/) is an extension of the highly successful programme that started with the Kamiokande experiment and continues with Super-Kamiokande (SuperK), which has yielded two Nobel prizes. HyperK is a water Cherenkov detector centred on a huge underground tank containing 300,000 tonnes of water, with a sensitive volume about a factor of 10 larger than its predecessor SuperK. Like SuperK, HyperK will be located in Kamioka on the west coast of Japan directly in the path of a neutrino beam generated 295 km away at the J-PARC facility in Tokai, allowing it to make high-statistics measurements of neutrino oscillations. Together with a near-detector located close to J-PARC, SuperK formed the T2K long-baseline neutrino programme. An order of magnitude more sensitive than SuperK, HyperK will serve as the next far-detector for Tokai-to-Kamiokande experiments, with a rich physics portfolio. This ranges from the study of the CP violation in

the leptonic sector and measurements of neutrino-mixing parameters, to studies of proton decay, atmospheric neutrinos and neutrinos from astrophysical sources. The staged Japanese neutrino programme allows for continuous production of world class physics results from T2K to the future HyperK experiments at the time it ensures the training of the new generation of neutrino physicists. The knowledge acquired both in detector operation and the understanding of physics processes will improve the precision of future experimental results.

The still growing Hyper-K proto-collaboration was formed in 2015 and is currently composed of around 300 members from 82 institutes coming from 17 countries. Prof. A. Blondel (University of Geneva) is a member of the Steering Committee of the HyperK proto-collaboration and Prof. F. Sanchez (University of Geneva) is currently the Swiss representative in the International Board of the project.

On 12 September 2018, the Japanese government granted seed funding towards the construction of the HyperK experiment for 2019, which will enable progress in preparatory work for construction and efforts to secure international collaboration. The construction of the HyperK detector is planned to begin in 2020.

National relevance

Neutrino physics is a main priority of experimental and theoretical particle and astroparticle physics in Switzerland. It is one of the three pillars of CHIPP, the Swiss Institute of Particle Physics. There is a long history of major achievements of Swiss groups, in particular on neutrino oscillations with the K2K (JP), OPERA (CERN and Gran Sasso National Laboratory), T2K (JP) and MicroBooNE (USA) experiments. The Swiss researchers involved in the Japanese effort have been recognised by the prestigious Breakthrough Prize in Fundamental Physics in 2016 for the discovery and exploration of neutrino oscillations, and the related Nobel prize in 2015.

The main subjects of neutrino physics in Switzerland are presently neutrino oscillations at long and short baselines, ultra-high energetic neutrinos from the cosmos and the neutrino-less double beta decay. The development of innovative detectors plays a crucial role in all of these activities, as well as the theoretical and phenomenological aspects of neutrino physics and the study of new particle accelerator infrastructures and technologies, i.e. at PSI. CERN as the European laboratory for Particle Physics being located in Switzerland is closely tied to the Swiss neutrino efforts and is an integral part of the global strategy by hosting the Neutrino Platform.

The approved LBNF/DUNE originates from the merging of the LBNO project in Europe (led by ETHZ) and LBNE, an early project initiated in the USA for beams and detectors. Swiss researchers are currently heavily engaged in the far and near detector design and construction: the University of Bern has led the design of the near detector based on past experience and is testing a prototype at Fermilab, while ETHZ is leading the dual-phase approach for the far apparatus. Very relevant, as well, is the theory group at the University of Basel contributing to the study of discovery prospects for new physics. Overall, the scientific impact and visibility of Switzerland is large and very well acknowledged.

Swiss groups (University of Bern, University of Geneva and ETHZ) have made considerable investments in the construction, operation and scientific exploitation of the T2K experiment. The ETHZ and University of Geneva are committed to the exploitation of the experiment until the end of the T2K operation. The University of Geneva is leading the R&D efforts to construct two of the subsystems for the near detector upgrade in close collaboration with the CERN Neutrino Platform. The T2K upgrade and the near detector infrastructures, to which Swiss groups made key contributions, are considered as the precursor of the HyperK. In addition, the University of Geneva is exploring a possible contribution to the readout electronics of the future HyperK inner detector sensors based on electronics boards developed at PSI, and is promoting possible contributions from CERN to the accelerator upgrade of the J-PARC facility.

Based on expertise, cooperation with previous experiments and industry partners, it is expected that Switzerland can play an important role in the mechanical site infrastructure and cryogenic equipment for LBNF/DUNE. Contributions to HyperK are also expected for the near detector facility infrastructure such as magnet or gas systems and the J-PARC beam upgrade, in cooperation with CERN, PSI and the Swiss industry.

These projects are part of the Swiss strategy for exploring neutrino physics as detailed in the 2015 whitepaper on neutrino physics in Switzerland. A commensurate contribution from Switzerland to these infrastructures would match and value, on the one hand, the merit of the science initiative, and on the other hand, the visible and substantial engagement of the Swiss groups. In order to support simultaneously LBNF/DUNE, the related work of Swiss groups and CERN as a centre for the European participation in large international neutrino experiments, SERI foresees a special contribution from the Confederation to CERN for the activities related to the LBNF/DUNE experiment involving Swiss groups. Such financial support will make use of already existing Swiss funds by CERN.