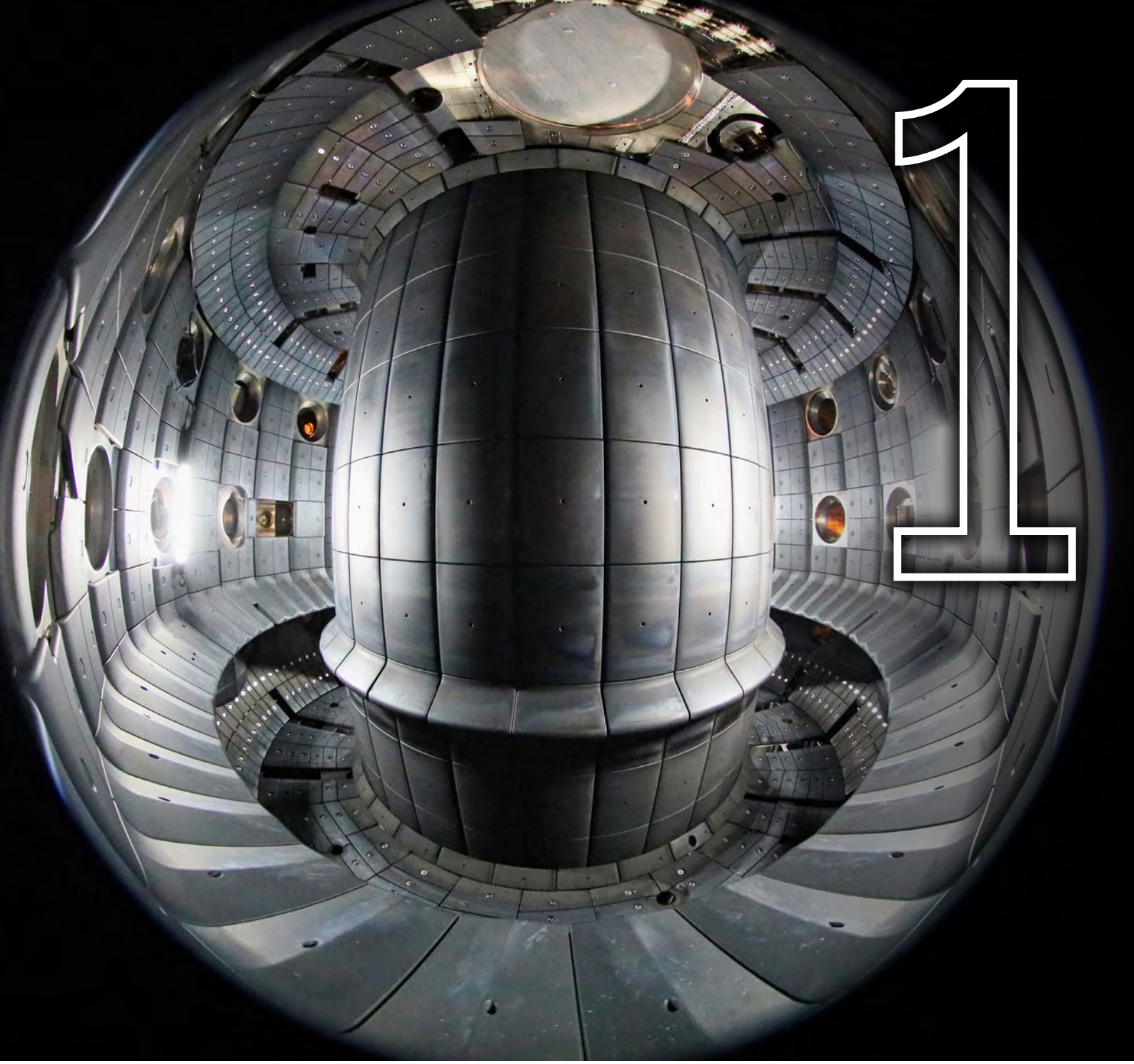

Swiss Roadmap for Research Infrastructures in view of the 2025–2028 ERI Dispatch (Roadmap for Research Infrastructures 2023)

Part I: National Research infrastructures

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
State Secretariat for Education,
Research and Innovation SERI

Cover photo: In the tokamak, scientists from the Swiss Plasma Center are working on nuclear fusion. This infrastructure has been listed on the Swiss Roadmap for Research Infrastructures since 2015. Photo: Alain Herzog, EPFL

Impressum

Publisher: © 2023 State Secretariat for Education, Research and Innovation SERI
Editor: Cyrille Girardin
Translated by: SERI Language Services and Federal Chancellery
Languages: English, German, French

Contact
Cyrille Girardin
Scientific Advisor, Division National Research and Innovation
cyrilleclaude.girardin@sbfi.admin.ch

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Management summary

The 2023 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 previous Roadmaps. It is one of the documents forming the basis for drawing up the 2025–2028 ERI Dispatch. This Roadmap also provides information on 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 loans.

Research and innovation are key to economic and social progress. Researchers in all disciplines rely on having excellent research infrastructures 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 infrastructures 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 research infrastructures which can be used across all 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 research infrastructures against that of discontinuing, developing or maintaining existing infrastructures.

The 2023 Swiss Roadmap for Research Infrastructures provides a general overview of new research infrastructures planned with a view to the 2025–2028 ERI Dispatch and updated information on those included in the 2015 and 2019 Roadmaps (with a view to the 2017–2020 and 2021–2024 ERI Dispatches) which also require funding going forward. However, the 2023 Roadmap does not contain an inventory of all existing infrastructures. A more comprehensive inventory including many infrastructures in use before the 2017–2020 funding 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 accordance with the Federal Act on the Promotion of Research and Innovation (RIPA). The proposals for research infrastructures in Switzerland put forward by researchers were first of all 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 levels of excellence: A, B and C. It also assessed the plausibility of the budget. 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 28 research infrastructures for implementation in Switzerland, 17 of which are new and 11 of which involve major upgrades of existing research infrastructures. Of the 28 projects evaluated by the SNSF, 15 (of which eight are upgrades) were assessed as being of high scientific importance (excellence level 'A'). Only those proposals which successfully passed the Phase 3 review are included in the 2023 Roadmap. The Confederation can also provide extraordinary support in accordance with Art. 47 para. 3 of the Higher Education Act (HEdA) to infrastructures operated by cantonal universities (or infrastructures supported by the latter) if they are in particularly costly areas or priority areas. This extraordinary funding was requested by swissuniversities for ten infrastructure projects. The funding decisions under Art. 47 para. 3 HEdA will be taken within the scope of the 2025–2028 ERI Dispatch.

As part of the process of compiling the Roadmap, the SNSF was also asked by SERI to examine the importance of Swiss participation in seven international infrastructures and organisations and to provide its opinion on their importance. The SNSF identified five of these as priority infrastructures ('high importance'). The results of these reviews are included in *Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks* and in *Roadmap for Research Infrastructures 2023: Part III Swiss participation in international research organisations.*

Overview of infrastructures in 2023 Roadmap

The national infrastructures from the 2015 and 2019 Roadmaps are listed in Annex I.

New national infrastructures (and major upgrades)

The national infrastructures listed below were put into the highest excellence level ('A') by the SNSF and were recommended by the responsible bodies to be included in the 2023 Roadmap. They are described in detail in the annexes.

- Sustained Scientific User Laboratory for Simulation and Data-based Science at CSCS (HPCN-28)
- Isotope and Muon Production using Advanced Cyclotron and Target Technologies (IMPACT)
- SwissBioData Ecosystem (SBDe)
- Swiss Data Science Center (SDSC+)
- Swiss Institute for Drug and Device Development (SI3D)
- EM Frontiers
- Swiss Biosites for Sustainable Agriculture and Agroecology (SISAL)
- Imaging and Omics Platform for Swiss Citizen Health (IOP4CH)
- Swiss Quantum Communication Infrastructure (Swiss-QCI)
- Swiss Fusion Hub
- A Swiss Geo-Time Research Infrastructure (Geo-TIME)
- Swiss Digital Pathology Initiative (SDPI)
- Airborne Research Facility for the Earth System (ARES)
- Operating Room X: A Translational Hub for Surgical Research and Innovation (OR-X)

Participations in international infrastructures

a) Existing international participations

Switzerland's current membership of international infrastructures will be continued. This applies to: ELIXIR, CERN, ESO, ESRF, ILL, European XFEL, ESS, EMBL, ITER, SKAO. They are described in greater detail in *Roadmap for Research Infrastructures 2023: Part III Swiss participation in international research organisations (ELIXIR in Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks).*

b) Previously recommended international participations and international participations for consideration

Switzerland does not yet participate (as a member) in the following infrastructures, but was recommended to do so in the 2019 Roadmap: BBMRI, CESSDA, DARIAH, ECRIN, EPOS, ICOS, ACTRIS, SHARE, ESSurvey, ECCSEL, eLTER, PRACE (the implementation status is detailed in table in *Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks).*

c) International participations examined in the 2023 Roadmap

The new participations recommended by the SNSF as part of the 2023 Roadmap process (category 'A') are as follows:

- Common Language Resources and Technology Infrastructure (CLARIN)
- European Infrastructure for Plant Phenotyping (EMPHASIS)
- The Generations and Gender Programme (GGP)
- Scientific Large-scale Infrastructure for Computing/ Communication Experimental Studies (SLICES)
- Cherenkov Telescope Array Observatory (CTAO)

1 Introduction

1.1 Content of the Roadmap report

The State Secretariat for Education, Research and Innovation (SERI) was responsible for drawing up this 2023 Roadmap for Research Infrastructures ('2023 Roadmap') and for the process conducted with its partners: the ETH Board, the Swiss Conference of Rectors of Higher Education Institutions (swissuniversities), the Swiss National Science Foundation (SNSF) and the Swiss Academy of Sciences (SCNAT).

The 2023 Roadmap is based on a set procedure and comprises three parts. Part I *(Roadmap for Research Infrastructures 2023: Part I National Research infrastructures*) begins by presenting the various measures in place aimed at promoting research infrastructures at national level (section 2). It goes on to describe the process carried out by the higher education institutions and the research institutes of the ETH Domain to select the projects and explains which new infrastructures are planned (sections 3 to 5). The annexes to Part I contain the scientific descriptions and budgets for the national infrastructure projects in the 2015 and 2019 Roadmaps (updates) and the 2023 Roadmap (new projects with implementation from 2025).

Part II *(Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks)* presents an update on Switzerland's participations in European infrastructure networks (section 4) and participations for future consideration (sections 2 and 3). It also provides scientific descriptions of these networks (Annexes II.1 and II.2). Part III *(Roadmap for Research Infrastructures 2023: Part III Swiss participation in international research organisations)* details the international organisations with which Switzerland is associated.

1.2 Aim of the Roadmap

Research infrastructures are an essential prerequisite for obtaining new scientific results, developing specialised fields or exploring new fields of research. Given the multidisciplinary nature of research together with trends in how data is used and exchanged, the need for such research infrastructures has increased in recent years and has led to a greater need for coordination. Furthermore, funding requirements have risen not only due to the increased number of infrastructures, but also because of their increasing complexity. This gives rise to the key issue of long-term funding. As such, medium- to long-term coordination is also required for major research infrastructures of national or international importance, as is careful planning to ensure that the 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 2023 Swiss Roadmap serves as a planning instrument and is one of the basis documents used by the Confederation to make budgetary decisions regarding the 2025–2028 ERI Dispatch. However, the Roadmap does not contain any funding decisions. This also applies for financial assistance in the start-up phase in accordance with Art. 47 para. 3 HEdA.

The funding decisions under the 2025–2028 ERI Dispatch regarding the realisation of the various research infrastructure projects in which funding is provided by the Confederation[1] are taken on the following bases:

- higher education institutions' strategic planning and the multi-year programmes of the relevant funding 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); and
- budgetary framework for multi-year financial decrees (ERI) as determined by the Federal Council for the 2025–2028 funding period.

1 See section 5.1 for an explanation of the Confederation's responsibilities.

ARES (Airborne Research Facility for the Earth System) is a research infrastructure in the field of Earth system sciences and consists of three high-precision Earth observation instruments. ARES has been listed on the Swiss Roadmap for Research Infrastructures since 2019. Image: ARES.

2 Research infrastructures in Switzerland

2.1 Introduction

At national level, numerous players provide support for research infrastructures that are used by scientists. New infrastructures for the cantonal universities and the ETH Domain are usually[2] selected via the Roadmap process described in the following sections. This principle was introduced in the Swiss Roadmap for Research Infrastructures in 2015. Federal funding bodies (the Swiss National Science Foundation and the Swiss Academies of Arts and Sciences) and the Confederation itself also contribute towards the development of the research infrastructure landscape, playing a subsidiary role in accordance with the Federal Act of on the Promotion of Research and Innovation (RIPA). The relevant infrastructures are developed outside of the Roadmap process. The following section provides a brief overview of the plans of the various players for the 2025–2028 ERI period.

2.2 ETH Domain

The Federal Council expects the ETH Domain to realise large-scale research infrastructures of national and international importance, to continue to operate and develop them, and to make them available to researchers. As such, the ETH Board will continue to provide adequate resources to existing infrastructures in the 2025–2028 funding period. As the 2023 Roadmap does not contain an inventory and instead focuses solely on new projects, this report will not further address the existing infrastructures in the ETH Domain. A description of the infrastructures discussed in the 2015 and 2019 Roadmaps can be found in the annexes. In addition to maintaining and developing existing infrastructures, the ETH Board has a strategic focus on projects which are selected as part of the 2023 Roadmap process (see sections 4 and 5).

2.3 Cantonal universities

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 Federal Act on Funding and Coordination of the Swiss Higher Education Sector (HEdA). The universities will continue to fund the projects submitted in the 2015 and 2019 Roadmaps (see annexes). The projects planned in the 2023 Roadmap for the 2025–2028 funding period are described in sections 4 and 5 and under certain circumstances, can receive financial support from the Confederation. As part of the current process, a source of funding has been introduced in accordance with Art. 47 para. 3 HEdA for the start-up of phase of research infrastructures which the universities run in particularly costly areas and which fall within the priority areas defined by the Swiss Conference of Higher Education Institutions (SHK) (see section 5.3).

2.4 Infrastructures of national importance

In accordance with Art. 15 RIPA, the Confederation provides basic contributions to research infrastructures of national importance. Infrastructures must apply for this subsidiary funding to be renewed every four years, with applications evaluated by the Swiss Science Council (SSC) on the basis of scientific criteria. For the 2025–2028 funding period, applications must be submitted by 30 June 2023 for the infrastructures already funded in the 2021–2024 funding period (14 infrastructures[3]) and the new infrastructures requesting funding under Art. 15 RIPA; these applications are dealt with separately from the Roadmap process. Taking into account the prioritisation set in the ERI Dispatch, the results of the SSC evaluation and the available funding, the Federal Department of Economic Affairs, Education and Research (EAER) will make a decision by the end of 2024 on which infrastructures will receive funding under Art. 15 RIPA in the 2025–2028 funding period.

2 The universities and the ETH Domain can independently decide on the research infrastructures to be selected and realised.
3 www.sbfi.admin.ch/forschungseinrichtungen-von-nationaler-bedeutung (in German, French, Italian)

2.5 Swiss National Science Foundation

The Swiss National Science Foundation (SNSF) will continue its policy of funding new data and service infrastructures in the 2025–2028 funding period, taking into account the specific needs of the science communities. In addition, the SNSF will continue to provide funding for two social science infrastructures: the Swiss Centre of Expertise in the Social Sciences (FORS) and the Data and Service Centre for the Humanities (DaSCH), two cohort studies in the healthcare sector (Swiss HIV Cohort Study and Swiss Transplant Cohort Study) and a biological database (Swiss Biobanking Platform). The issue of longer-term funding of data infrastructures in other areas, in particular with regard to ERIC infrastructures, is still being discussed with the ERI partners. The SNSF is planning to finance the equipment via additional project funding. International research infrastructures in the areas of particle physics, astrophysics and astroparticle physics will be funded via the FLARE (Funding Large International Research Projects) programme.

As part of its multi-year planning for the 2025–2028 funding period, the SNSF will provide the following funding to research infrastructures. These are planned amounts, which may still be adjusted in line with the budgetary framework of the 2025–2028 ERI Dispatch.

Infrastructure type	**2025–2028 budget (in CHF m; as of March 2023)**
Instruments (FLARE)	44.0
Data infrastructures FORS DaSCH	 32.8 9.2
Healthcare infrastructures SCTO Swiss Biobank Platform Cohort studies	Exact amounts are yet to be determined.
Other infrastructures	Exact amounts are yet to be determined.
Total	**108,0**

Conclusion:

- The SNSF will continue to fund existing data infrastructures (FORS, DaSCH) and will examine the possibility of funding new infrastructures. It will also continue to fund cohort studies.
- Within the scope of the available resources, it will also provide targeted funding for measures as part of the open research data (ORD) strategy.
- The SNSF establishes and funds research infrastructures that fall within its responsibility using resources apportioned to it in the 2025–2028 ERI Dispatch (funding envelope).

2.6 Swiss Academies of Arts and Sciences

In its 2025–2028 multi-year programme, the Swiss Academy of Humanities and Social Sciences **SAHS** proposes funding the following research infrastructures with a budget of CHF 58.70 million. These are planned amounts, which may still be adjusted in line with the budgetary framework of the 2025–2028 ERI Dispatch.

Editions	CHF 14.29m

Long-term undertakings (continued)	CHF 44.41m

In its 2025–2028 multi-year programme, the Swiss Academy of Sciences **SCNAT** proposes funding the following research infrastructures with a budget of CHF 9.28 million. These are planned amounts, which may still be adjusted in line with the budgetary framework of the 2025–2028 ERI Dispatch.

Science secretariats	CHF 9.28m

In its 2025–2028 multi-year programme, the Swiss Academy of Medical Sciences **SAMS** proposes funding the following research infrastructures with a budget of CHF 21 million. These are planned amounts, which may still be adjusted in line with the budgetary framework of the 2025–2028 ERI Dispatch.

Data coordination centre for clinical data and healthcare data	CHF 21.00m
Total funding by the Swiss Academies of Arts and Sciences	**CHF 88.98m**

Conclusion:

- Funding for research infrastructures within the Academies' remit is met from the funding envelope awarded to the Swiss Academies of Arts and Sciences in the 2025–2028 ERI Dispatch.
- The Swiss Academies of Arts and Sciences will also provide targeted funding for measures determined as part of the national ORD (open research data) strategy.

3 Swiss Roadmap for Research Infrastructures 2023

3.1 Objective and purpose in accordance with RIPA

This Roadmap provides an overview of newly planned research infrastructures (see Annex I.1) and an update on the implementation of infrastructure projects outlined in the 2015 and 2019 Roadmaps (Annex I.2). It thus acts as an instrument for ensuring coherence between research funding measures at national and international level (Art. 41 RIPA and Art. 55 RIPO).

The Roadmap is based on the European definition of a 'research infrastructure'[4], which includes the following criteria:

- The research infrastructure makes a major contribution to the development of a field of research (academic added value and innovation).
- The research infrastructure is used intensively by researchers in Switzerland (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 infrastructure must also meet the following criteria[5] (these criteria were introduced in the 2019 Swiss Roadmap and have been incorporated into the 2023 Roadmap):

- The research infrastructure is new or a significantly upgraded existing infrastructure.
- The level of maturity of the research infrastructure is advanced; implementation is imminent.
- The research infrastructure has investment and operating costs of at least CHF 5 million for the 2025–2028 period funding 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 (see section 2.5). The Confederation, meanwhile, is responsible for subsidiary support for research infrastructures of national importance (Art. 15 RIPA) and in this process, for funding infrastructures in particularly costly areas (see Art. 47 para. 3 HEdA) and for Switzerland's participation in research infrastructures networks coordinated at international level (see section 5.1).

4 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:347:0104:0173:EN:PDF (Art. 2 para. 6).
5 2023 Swiss Roadmap for Infrastructures (in view of the 2025–2028 ERI Planning); Objectives, process and criteria: a guide (de/fr only).

3.2.2 Procedure

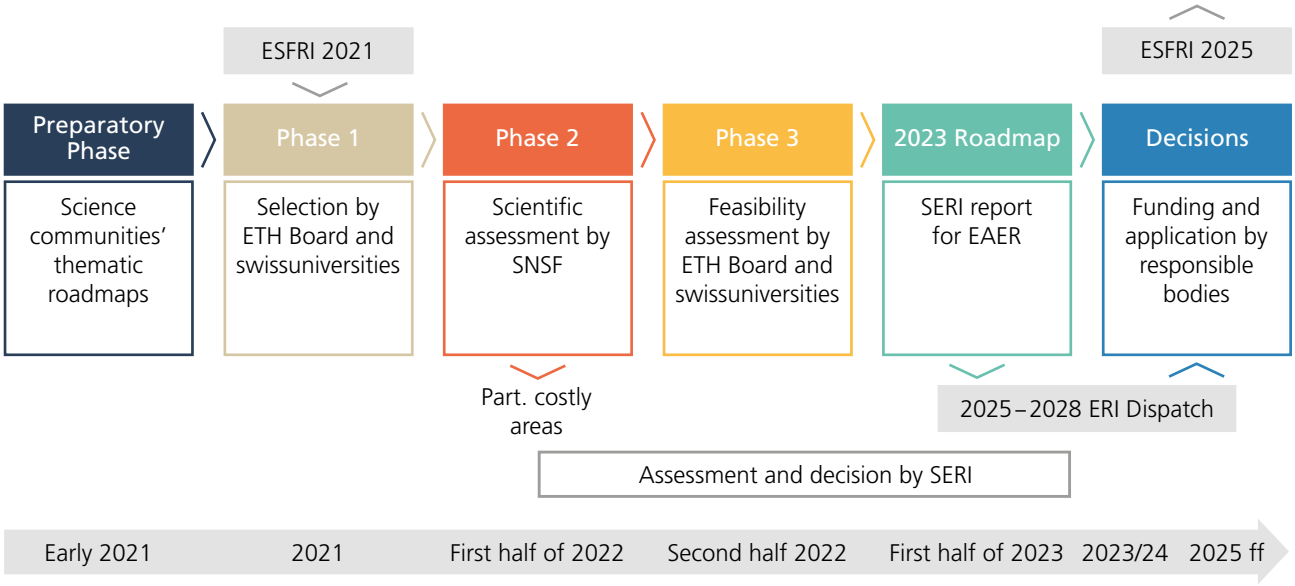

Figure 3.1: Procedure for new national infrastructure projects.

a) Newly planned national research infrastructures

Preparatory phase: This is a new phase in the 2023 Roadmap process. At the start of 2021, the Swiss Academy of Sciences (SCNAT) – at the request of SERI – published a number of thematic roadmaps for different areas[6]. These roadmaps were developed by the relevant scientific communities under the leadership of the SCNAT. The thematic roadmaps are used to determine the priorities of the various scientific communities so that Switzerland can maintain its leading position in this area and identify any deficiencies. They provide an overview of major future projects, taking into account the existing infrastructures, which may have to be improved as required. The thematic roadmaps were then used by the leadership teams at the higher education institutions and research institutes in the ETH Domain when identifying the newly planned infrastructures in Phase 1.

Phase 1: Between March and December 2021, the responsible bodies (swissuniversities and the ETH Board) made an inventory of newly planned research infrastructures (first evaluation stage or preselection, see section 4).

Phase 2: Phase 2 (January to July 2022) involved a scientific evaluation (second evaluation stage) by the SNSF of the infrastructures that the responsible bodies selected during Phase 1. On the basis of this evaluation, the infrastructures were prioritised according to the criteria listed in section 4 of this document. The further selection procedure only considered research infrastructure projects classed at the highest excellence level ('A'). The SNSF's evaluation thus led to a further selection. The SNSF also commented on the importance of Swiss participation in the international infrastructures proposed by the scientific communities.

Phase 3: The infrastructure projects in category 'A' were examined in more detail by the responsible bodies between July and December 2022, which also involved assessing the feasibility of the projects (governance, management, financing). The detailed description of each of these infrastructures can be found in Annex I.1.

b) Update of national research infrastructure data in the 2015 and 2019 Roadmaps

Current data on the research infrastructures newly planned in the 2015 and 2019 Roadmaps was gathered from the responsible bodies (swissuniversities and ETH Board). The updated information (as of January 2023) can be found in Annex I.2.

6 A thematic roadmap was produced for the following areas: astronomy, biology, chemistry, geosciences, neutron science, photon science as well as particle and astroparticle physics.

c) European and international research infrastructures

The two types of international research infrastructures mentioned in Art. 28 para. 2 RIPA are also part of the Roadmap:

- 'International research facilities' (e.g. CERN or ESO). These organisations construct, develop and maintain centralised facilities, which may be accessed by external users. They require substantial long-term investment as well as operational and maintenance funding from their member states. As Switzerland's participation in these projects is costly and represents a long-term commitment, each individual international research infrastructure requires special federal monies earmarked in the scope of the ERI or specific dispatches. New projects carried out within the framework of international research facilities of which Switzerland is already a member are therefore given funding priority. Of secondary importance is the continued participation in international research organisations to which Switzerland is associated for a set period of time. Finally, joining other existing or new international research organisations is Switzerland's third priority. Detailed information on the international research facilities of which Switzerland is a member can be found in *Roadmap for Research Infrastructures 2023: Part III Swiss participation in international research organisations.*
- 'Internationally coordinated research infrastructures', such as EPOS or ECRIN. They comprise national nodes spread out around the world, which pool their services and resources (e.g. instruments, data, expertise) in a single research infrastructure via coordination and cooperation agreements. Coordinated research infrastructures make it possible to harmonise practices, establish standards, centralise data processing and provide members with a variety of services and mutual access. The individual research infrastructures are brought together in the European Strategy Forum on Research Infrastructures (ESFRI), which helps ensure a coherent and strategic approach across the European infrastructure landscape. As autonomous institutions, higher education institutions (or research institutes) can participate in ESFRI projects. The Confederation only has direct responsibility when this participation is part of an international agreement, for example when an ESFRI project adopts the legal form of a European Research Infrastructure Consortium (ERIC). ERICs are becoming increasingly common. Information on this type of infrastructure and the procedure for examining new Swiss participation can be found in *Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks.*

4 First and second evaluation stages (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 major upgrades. As mentioned in section 3, the higher education institutions and research institutes in the ETH Domain were here able to make use of the thematic roadmaps produced by the scientific communities. In a first step, the sponsoring institutions (higher education institutions and research institutes in the ETH Domain) submitted rough outlines of the new infrastructures, and these were assessed in terms of their alignment with the strategic planning of the ETH Domain or the higher education institutions concerned and with regard to the criteria set out in section 3.1.

The responsible bodies selected 33 new projects (Phase 1). Commissioned by SERI, the SNSF then assessed 28 of these[7] (Phase 2), applying the following criteria:

- Scientific quality
- National (and international) importance
- Accessibility and user groups
- Scientific feasibility
- Plausibility of costs.

On the basis of the SNSF's evaluation, the infrastructures were categorised into three excellence levels:

Excellence level A	High scientific relevance	15 projects
Excellence level B	Medium scientific relevance	12 projects
Excellence level C	Low scientific relevance	1 project

4.2 Overview by field and institution

The 28 research infrastructures reviewed by the SNSF span four main fields, as follows:

- Humanities and Social Sciences: 1
- Science, Technology, Engineering and Mathematics (STEM): 8
- Life Sciences: 15
- e-infrastructures: 4

The following sponsoring institutions submitted new projects:

- ETH Domain: 8
- Cantonal universities: 22
- Universities of applied sciences: 1

The total of these figures is 31 because three proposals were jointly submitted by the ETH Domain and the cantonal universities.

The funding volume required for all 28 new projects was estimated at around CHF 1.1 billion (total investment and operating costs for 2025–2028, as at January 2022). The 15 projects classed by the SNSF as category 'A' account for a funding volume of CHF 788.1 million.[8]

7 Some projects were not ultimately submitted, others were merged.
8 This funding requirement was increased, confirmed or reduced following an in-depth financial assessment (third evaluation stage).

5 Third evaluation stage (Phase 3) 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 the Swiss Academies of Arts and Sciences) 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 research infrastructures if such participation is the subject of an international treaty (Art. 28 RIPA).

In the ETH Domain, it is the ETH Board, the two federal institutes of technology ETH Zurich and EPF Lausanne and the four research institutes (Paul Scherrer Institute PSI, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Swiss Federal Laboratories for Materials Science and Technology Empa, Swiss Federal Institute of Aquatic Science and Technology Eawag) that are responsible for creating their own research infrastructures, in accordance with the ETH Act and within the scope of the Federal Council's strategic objectives for the ETH Domain (this may also involve third-party funding). Meanwhile, under the Federal Act on the Funding and Coordination of the Higher Education Sector (HEdA), the cantonal universities receive subsidiary funding in the form of basic contributions from the Confederation for research infrastructures within the competence of the cantonal universities (universities and universities of applied sciences). To help fund the costly start-up phase of research infrastructures, in this Roadmap the Confederation has introduced an additional subsidiary form of financial support with a limited duration within the scope of the existing instruments (Art. 47 para. 3 HEdA) (see section 5.3).

In view of the above, all 28 projects evaluated by the SNSF in Phase 2 fell within the competence of the ETH Board (five projects) or swissuniversities (20 projects, including 19 projects by cantonal universities and one from a university of applied sciences). Three projects fall within the joint competence of both bodies.

Both responsible bodies carried out Phase 3 of the evaluation according to their own procedure for projects classed in category 'A' by the SNSF (15 projects in total). Common criteria from the Roadmap 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 recommended that all 15 projects in category 'A' (high scientific relevance) be put forward for an in-depth study with regard to their implementation. Two projects were merged at this stage in the process, meaning 14 infrastructures were treated as a priority. Table 5.1 provides an overview of these research infrastructures, ordered according to financial volume. The total estimated costs for the 2025–2028 funding period amount to approximately CHF 788 million, of which around CHF 550 million is to be borne by the Confederation (as of January 2023). Figure 5.1 shows the distribution of costs by academic field for the 14 projects recommended by the responsible bodies.

5.3 Extraordinary support in accordance with Art. 47 para. 3 HEdA

As part of the 2023 Roadmap process, the Confederation – based on the existing Art. 47 para. 3 of the Higher Education Act (HEdA) – introduced a form of extraordinary support for new research infrastructures operated by the cantonal universities. Financial assistance is usually limited to a four-year period and must be used for investment and operational costs in the start-up phase. The Confederation covers up to 50% of the costs. Further criteria include the following:

- The project is part of the strategic planning of swissuniversities[9] and the higher education policy priorities.
- The SNSF has classed the research infrastructure project as the highest excellence level (category 'A').
- The infrastructure project is in a 'particularly costly area' as per the definition in Art. 40 HEdA or in a priority area as determined by the Swiss Conference of Higher Education Institutions (SHK).[10]
- The project is coordinated at national level and demonstrably provides efficiency gains without compromising on quality.
- For the four years of the 2025–2028 ERI period, the investment and operational costs of the planned research infrastructure amount to at least CHF 10 million.

Based on these criteria, swissuniversities requested extraordinary support for ten projects in accordance with Art. 47 para. 3 HEdA (see table 5.3).

Seven of the projects proposed by swissuniversities are in the area of data infrastructures. SERI has therefore asked the Open Research Data (ORD) Strategy Council, which was set up at the beginning of 2022, whether it considers the proposed projects to be part of the ORD landscape in accordance with the ORD Strategy and the ORD Action Plan. By the start of 2024, depending on the resources available under the 2025–2028 ERI Dispatch, SERI – in consultation with the Swiss Conference of Higher Education Institutions (SHK) – will decide which infrastructure projects proposed by the cantonal universities can receive funding in accordance with Art. 47 para. 3 HEdA (subject to the funding granted by Parliament as part of the 2025–2028 ERI Dispatch).

The goal of the IMPACT project is to enable significantly better experiments in particle physics, material sciences, life sciences and medicine by constructing two new facilities at the existing proton accelerator. HIMB is listed for the first time in the Swiss Roadmap for Research Infrastructures 2023. Picture: Paul Scherrer Institute/Mahir Dzambegovic.

9 See Annex 4 of the Strategic planning of swissuniversities (in German/French).
10 The four priority areas are as follows: i) infrastructures and services for the generation, processing and storage of scientific data and information, ii) high-performance computers, iii) imaging processes and iv) livestock farming and animal testing.

Table 5.1: Priority infrastructures and costs for the 2025–2028 funding period following completion of the Roadmap process

Field	Institution(s)	Project	Total costs (CHF m)[11]	Federal costs (CHF m)
e-infrastructures	ETH Zurich	Sustained Scientific User Laboratory for Simulation and Data-based Science at CSCS (HPCN-28)	205.0	189.0
STEM	PSI, UZH	Isotope and Muon Production using Advanced Cyclotron and Target Technologies (IMPACT)[12]	93.4	80.3 (of which 4.5 under Art. 47)
Life sciences and medicine	(See Annex I.1)	SwissBioData Ecosystem (SBDe)	90.7	44.1 (of which 24.2 under Art. 47)
e-infrastructures	EPFL, ETH Zurich, PSI	Swiss Data Science Center+ (SDSC+)	80.0	60.0
Life sciences and medicine	UZH	Swiss Institute for Drug and Device Development (SI3D)	68.2	19.9 (Art. 47)
Life sciences and medicine	EPFL, ETH Zurich, PSI, Empa, UNIL, UNIBAS, UNIBE, UNIGE, UZH	EM Frontiers[13]	53.8	41.0 (of which 11.0 under Art. 47)
Life sciences and medicine	(See Annex I.1)	Imaging and Omics Platform for Swiss Citizen Health (IOP4CH)	45.9	23.0 (Art. 47)
Life sciences and medicine	ETH Zurich, WSL, Empa, Eawag, EPFL	Swiss Biosites for Sustainable Agriculture and Agroecology (SISAL)	37.9	34.4
e-infrastructures	UNIGE	Swiss Quantum Communication Infrastructure (Swiss-QCI)	24.8	12.2 (Art. 47)
STEM	EPFL, PSI	Swiss Fusion Hub	24.3	19.3
STEM	UNIL, UNIGE, UNIBE, EPFL, ETH Zurich	A Swiss Geo-Time Research Infrastructure (Geo-TIME)	22.4	8.9 (of which 6.8 under Art. 47)
Life sciences and medicine	UZH, UNIBE, UNIBAS, UNIGE, UNIL	Swiss Digital Pathology Initiative (SDPI)	18.4	9.1 (Art. 47)
Life sciences and medicine	UZH	Operating Room X: A Translational Hub for Surgical Research and Innovation (OR-X)	13.1	3.7 (of which 3.3 under Art. 47)
STEM	UZH	Airborne Research Facility for the Earth System (ARES)	10.2	5.0 (Art. 47)
Total			**788.1**	**549.9**

Annex I.1 of this Roadmap contains detailed descriptions of these proposed research infrastructures.

11 The detailed budget can be found in Annex I.1.
12 Project within joint competence of ETH Board and swissuniversities.
13 Project within joint competence of ETH Board and swissuniversities.

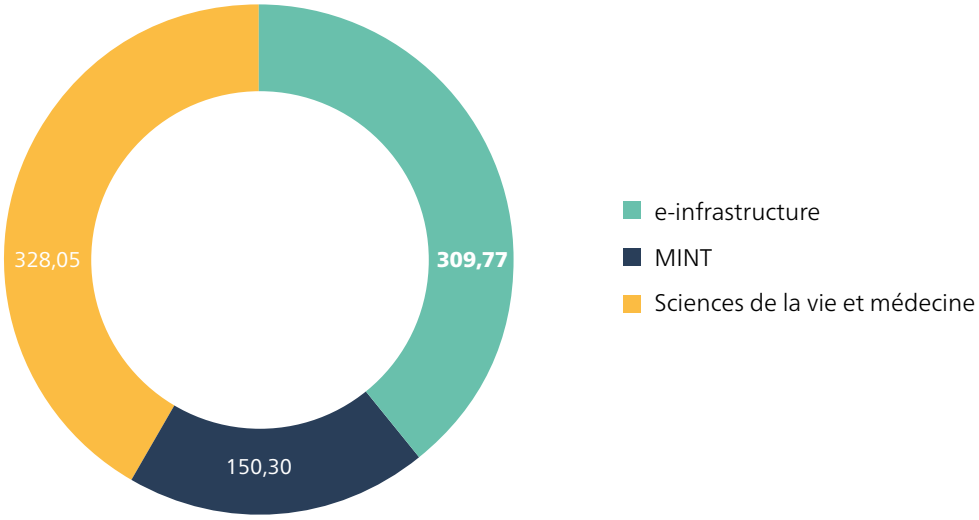

Figure 5.1: Distribution of funds by field (n=14 projects recommended for a total of CHF 788,1 million).

a) ETH Domain (as of January 2023)

In accordance with the Strategic Plan 2025–2028 of the ETH Board for the ETH Domain[14], the research infrastructures shown in table 5.2 are of particular strategic importance. Having been assessed positively, the six proposed projects listed in this table (including the joint projects with swissuniversities) were recommended by the ETH Board for inclusion in the 2023 Roadmap.

An estimated CHF 494.4 million in funding is required for the 2025–2028 funding period to fully realise these six research infrastructure projects (four upgrades, two new projects), of which CHF 408.5 million will come from the ETH Domain funding envelope (with CHF 282.5 million of this being provided by the ETH Board via centrally planned resources). If the ETH Board is unable to provide the required funding from the funding envelope yet to be determined by Parliament for 2025–2028, it will decide at an appropriate time how to fund the projects in accordance with its financial capacities.

In addition to investment in 2023 Roadmap research infrastructures, substantial resources will be made available in the 2025–2028 ERI period for operating and developing or expanding existing research infrastructures (see the Strategic Plan 2025–2028 of the ETH Board for the ETH Domain).

Conclusion:

- The six proposed research infrastructures will require CHF 408.5 million in funding from the Confederation (as sponsor of the ETH Domain) in the 2025–2028 ERI period.
- The actual amount of funding available will be set via the ETH Domain funding envelope in the 2025–2028 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 2025–2028 ERI period.

14 Strategic Plan 2025–2028 of the ETH Board for the ETH Domain, 2022.

Table 5.2: ETH Domain priority infrastructures

No.[15]	Research infrastructure	Main sponsoring institution	Estimated funding requirement 2025–2028 (CHF m)	Amount met by ETH Domain funding envelope (CHF m)
1	Sustained Scientific User Laboratory for Simulation and Data-based Science at CSCS (HPCN-28)	ETH Zurich	205.0	189.0
2	Isotope and Muon Production using Advanced Cyclotron and Target Technologies (IMPACT)[16]	PSI and UZH	93.4	75.8
4	Swiss Data Science Center+ (SDSC+)	EPFL	80.0	60.0
6	EM Frontiers[17]	EPFL and multiple universities[18]	53.8	30.0
8	Swiss Biosites for Sustainable Agriculture and Agroecology (SISAL)	ETH Zurich	37.9	34.4
10	Swiss Fusion Hub	EPFL	24.3	19.3
Total			**494.4**	**408.5**

15 Detailed information can be found in Annex I.1. The projects are numbered in the same way as here.
16 Project within joint competence of ETH Board and swissuniversities.
17 Project within joint competence of ETH Board and swissuniversities.
18 Universities of Bern, Basel, Lausanne, Geneva and Zurich.

b) Cantonal universities (as at January 2023)

The following ten projects were evaluated and approved by swissuniversities as part of the cantonal universities' strategic planning (including two projects within the joint competence with the ETH Board). In addition, swissuniversities requested extraordinary support from SERI for these ten projects in accordance with Art. 47 para. 3 HEdA. SERI will make a decision on these requests at the start of 2024, subject to the funding granted by Parliament as part of the 2025–2028 ERI Dispatch at the end of 2024.

An estimated CHF 440.9 million is required to fully implement these ten research infrastructures, of which CHF 119 falls under Art. 47 para. 3 HEdA.

Conclusion:

- Full realisation of these ten new research infrastructures would cost the Confederation CHF 141.4 million, via projects with the ETH Domain, contributions in accordance with Art. 47 para. 3 HEdA and funding requests in accordance with Art. 15 RIPA.
- A decision on any additional support under Art. 47 para. 3 HEdA will be made in 2024 in the budgetary framework of the 2025–2028 ERI Dispatch.
- The responsible universities decide whether these new research infrastructures are set up and how much funding they will receive in the 2025–2028 ERI period.

c) Confederation

The Confederation is not directly responsible for any of the projects. Funding requests for research infrastructures of national importance (Art. 15 RIPA) are subject to a separate procedure. Applicants are required to submit their proposals by 30 June 2023 (Art. 12 O-RIPA-EAER, SR 420.111). These proposals will be evaluated by the Swiss Science Council and the final decision will be made by the EAER at the end of the year 2024 in line with Parliament's financial decisions regarding the 2025–2028 ERI Dispatch.

Furthermore, the Confederation will support cantonal universities' infrastructure projects, in consultation with the SHK, based on Art. 47 para. 3 of the Higher Education Act (HEdA). The procedure for this extraordinary funding is described in section 5.3.

Table 5.3: Cantonal universities' priority infrastructures

No.[19]	Research infrastructure	Main sponsoring institution	Estimated funding requirement 2025–2028 (CHF m)	Applications under Art. 47 para. 3 (CHF m)	Amount met by Confederation, excl. Art. 47 para. 3 (CHF m)
2	Isotope and Muon Production using Advanced Cyclotron and Target Technologies (IMPACT)[20]	UZH and PSI	93.4	4.5	(75.8) see table 5.2
3	SwissBioData Ecosystem (SBDe)	UNIBE and SIB	90.7	24.2	19.9
5	Swiss Institute for Drug and Device Development (SI3D)	UZH	68.2	19.9	--
6	EM Frontiers[21]	Multiple universities[22] and EPFL	53.8	11.0	(30.0) see table 5.2
7	Imaging and Omics Platform for Swiss Citizen Health (IOP4CH)	UNIBAS and SwissTPH	45.9	23.0	--
9	Swiss Quantum Communication Infrastructure (Swiss-QCI)	UNIGE	24.8	12.2	--
11	A Swiss Geo-Time Research Infrastructure (Geo-TIME)	UNIL	22.4	6.8	2.1
12	Swiss Digital Pathology Initiative (SDPI)	UZH	18.4	9.1	--
13	Operating Room X: A Translational Hub for Surgical Research and Innovation (OR-X)	UZH	13.1	3.3	0.4
14	Airborne Research Facility for the Earth System (ARES)	UZH	10.2	5.0	--
Total			**440.9**	**119.0**	**22.4**

19 Detailed information can be found in Annex I.1. The projects are numbered in the same way as here.
20 Project within joint competence of ETH Board and swissuniversities.
21 Project within joint competence of ETH Board and swissuniversities.
22 Universities of Bern, Basel, Lausanne, Geneva and Zurich.

6 Conclusion and outlook

The 2023 Roadmap is the fourth edition of this report. The tables below show the developments and changes over time.

		Roadmap for Research Infrastructures (RIs)			
		2011	**2015**	**2019**	**2023**
National level	**Includes national RIs**	No	Yes	Yes	Yes
	Formal criteria before scientific evaluation of national RIs	*(No national RIs)*	European definition	• Europ. definition • New RI[23] • Maturity • Costs > CHF 5m	• Europ. definition • New RI[24] • Maturity • Costs > CHF 5m
	Special funding from Confederation for national RIs	*(No national RIs)*	No	No	Yes[25]
	Inventory of national RIs	*(No national RIs)*	Yes	No	No
International level	**Includes international RIs**	Yes	Yes	Yes	Yes
	Formal criteria for international RIs and ERICs	Interest in Swiss participation	Interest in Swiss participation	Interest in Swiss participation	Interest in Swiss participation
Process	**Permanent working group with ERI partners**	No	Yes	Yes	Yes
	Coordination of evaluation of national and international RIs	*(No national RIs)*	No	No	Yes[26]
	Further measures	--	--	--	• Thematic roadmaps • Check of alignment with ORD strategy

23 New research infrastructure or major upgrade.
24 New research infrastructure or major upgrade.
25 Support for start-up phase, usually limited to four years (Art. 47 para. 3 HEdA, see section 5.3).
26 The importance of new Swiss participations in international infrastructures was examined by the SNSF at the same time as the scientific evaluation of new national infrastructure projects was carried out.

The research infrastructures proposed in this 2023 Roadmap reflect the planning status as of the end of January 2023.

The EAER (SERI) is required to consider the funding bodies' multi-year programmes which feature in the 2023 Swiss Roadmap and to submit to the Federal Council with the 2025–2028 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 on the implementation of the projects selected in the 2015 and 2019 Roadmaps. Furthermore, it serves as a basis for the coordination necessary between the planning of national research infrastructures and that of European (ESFRI Roadmap) and international research infrastructures (see *Roadmap for Research Infrastructures 2023: Part II Swiss participation in international research infrastructure networks*).

However, this Roadmap does not contain any decisions on the amount or allocation of any federal monies earmarked in the 2025–2028 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, it is the ETH Board, the two federal institutes of technology ETH Zurich and EPFL and the four research institutes (PSI, WSL, Empa and Eawag) that are responsible for creating their own research infrastructures, in accordance with the ETH Act and within the scope of the Federal Council's strategic objectives for the ETH Domain. With regard to research infrastructures 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 the Swiss Academies of Arts and Sciences. 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 2025–2028 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 2027, SERI and its partners will examine the process and adapt it accordingly.

7 List of abbreviations

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
ETH, EPF	Federal institute of technology
HEdA	Federal Act on Funding and Coordination of the Higher Education Sector (SR 414.20)
ORD	Open research data
PSI	Paul Scherrer Institute (ETH Domain)
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
SHK	Swiss Conference of Higher Education Institutions (in accordance with HEdA)
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)

8 Annex I

Annex I.1: New (or substantially upgraded) national infrastructure projects in the 2023 Roadmap

Annex I.2: Update of national infrastructures from the 2015 and 2019 Roadmaps

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 2025–2028 and 2029–2032 are forecasts and are only given as a rough estimate of probable future costs and how these will be allocated.**
3) **Last information update: December 2022 to January 2023**

1. Sustained Scientific User Laboratory for Simulation and Data-based Science at CSCS (HPCN-28)

Category: e-Infrastructure
Host institution(s): ETH Zurich
Main funding sources: ETH Board, ETH Zurich
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Swiss National Supercomputing Centre in Lugano (CSCS) develops and operates an open access research infrastructure (RI) for extreme-scale scientific computing and data processing. This RI is a User Laboratory for supercomputing and organised around two main programs: i) a User Program that provides global access to CSCS supercomputing resources; and ii) a development program of supercomputing applications and expertise that is organised under the Platform for Advanced Scientific Computing (PASC) that is accessible to researchers based in Switzerland. Additionally, several Swiss institutions, national RIs, user facilities, and research projects benefit directly from the economies of scale reached at CSCS thanks to the HPCN-funded infrastructure having dedicated access to resources and services at CSCS. A very substantial societal impact of the HPCN initiative is the development of technologies for weather and climate modelling, and their direct benefits for the Federal Office of Meteorology and Climatology (MeteoSwiss)

Detailed description
Currently, the CSCS User Laboratory is among the leading RIs of its kind globally. Its successful flagship supercomputer Piz Daint has led to increasing scientific output by scientists in most domains and institutions in Switzerland. Since 2017, CSCS has provided state-of-the-art supercomputing and data services using a conventional HPC system architecture and cloud-native solutions. With the HPCN-24 upgrade, CSCS is introducing a data centre infrastructure dubbed Alps that implements a cloud-native architecture directly on the supercomputer. Cloud-native technologies enable us to target workflows, data, and computing usages of emerging and challenging science domains.

Within HPCN-28, CSCS will upgrade its infrastructure to continue to lead worldwide by providing researchers access to extreme-scale supercomputing and data services on advanced, geo-redundant data centre infrastructures that combine the virtues of HPC and cloud-native technologies. It will furthermore continue its successful PASC initiative of evolving application software for energy-efficient simulations and data analysis, and its established application-driven co-design approach to the development of supercomputers.

Access to the User Laboratory is th rough an open and transparent peer-review process for both researchers and research communities. There are two tiers of allocations researchers can apply for: Tier 1 projects for up to one million node-hours p.a. are allocated by a panel of eminent, non-Swiss scientists that include the members of the CSCS Scientific Advisory Board (SAC), and Tier 0 for larger projects accessible to researchers worldwide. Announcements of Tier 0 calls are made at the European level. The structure of both processes is similar, being based on peer review and scientific excellence. Community access to tailored data and workflow platforms will be based on their reviewed and sponsored scientific roadmaps, and regular review of readiness for compliance with and achievement of roadmap milestones.

b. International level
All infrastructure resources made available through the User Program 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 European perspective, in recent years approximately 40% of CSCS resources have been made available via the Partnership for Advanced Computing in Europe (PRACE), at which Switzerland (ETHZ) participates. As the relationship between Europe and Switzerland, in particular the path taken by EuroHPC, is continually evolving, the precise future implementation of international access remains open, and CSCS will be flexible and open to all possible developments. We will continue to pursue the established path and Switzerland's tradition of open access to research infrastructures, and we will continue to focus on bilateral and multilateral collaboration with other research infrastructures and science communities. The software strategy followed with the PASC programme is internationally recognised as exemplary. The software frameworks developed for the

weather and climate domain, for example, will support major European models such as the IFS of the European Centre for Medium-Range Weather Forecasts (ECMWF), or the ICON model developed by the Max Planck Institute (MPI) 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. The Alps infrastructure and the associated ecosystem being developed at CSCS, means that Switzerland will continue to be in the league of leading countries in scientific computing in Europe and worldwide.

c. Development prospects

Computing technologies, including both hardware and software layers, have to be continually renewed to remain competitive and (energy) efficient. In the post-Moore's Law era, increasing hardware variety, and rapid evolution driven by novel cloud-native and data-driven approaches require an active pursuit of new technologies. The HPCN initiative provides a funding envelope for investments enabling the design and preparation of applications, and the implementation of a competitive data centre infrastructure, as well a commitment from ETH Zurich to fund User Lab operations (estimated operating costs are based on 2021 electricity prices at CHF 0.14 per kWh). The resulting expertise with operating geo-redundant, cloud-native technology will be essential to operate infrastructure at the scale needed in the near future, e.g., for digital twins of the earth, which will require locating infrastructure close to electricity and cooling sources that are green and economically competitive.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution		Higher Education Institution		Higher Education Institution	
ETH, EPFL, Swiss Univ. (PASC)	12.00	ETH, EPFL, Swiss Univ. (PASC)	16.00	ETH, EPFL, Swiss Univ. (PASC)	20.00
Canton	0	Canton	0	Canton	0
Swiss Confederation		Swiss Confederation		Swiss Confederation	
ETH Board	122.00	ETH Board	100.00	ETH Board	150.00
ETH Zurich (operations)	78.00	ETH Zurich (operations)	89.00	ETH Zurich (operations)	84.00
Third parties	0	Third parties	0	Third parties	0
Total budget	**212.00**	**Total**	**205.00**	**Total**	**254.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	110.00	Investments	84.00	Investments	130.00
Operating costs	78.00	Operating costs	89.00	Operating costs	84.00
Other costs	24.00	Other costs	32.00	Other costs	40.00
Total costs	**212.00**	**Total**	**205.00**	**Total**	**254.00**

Development Phases	**Years**
Design	2024–2025
Preparation	2025–2028
Implementation	2025–2028
Operation	2024–2032

2. Isotope and Muon Production using Advanced Cyclotron and Target Technologies (IMPACT)

Category: instrument and associated delivery facilities
Host institution(s): PSI, UZH
Main funding sources: ETH Board, Swiss Confederation (SERI)[27], PSI, UZH
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The IMPACT project aims to produce and fully exploit unprecedented intensities and quantities of muons and radionuclides at the High Intensity Proton Accelerator (HIPA) for advancements in particle physics, chemistry, materials science, life sciences, medicine, and clinical research. Two new target stations, one for High-Intensity Muon Beams (HIMB), and one for the Targeted Alpha Tumor Therapy and Other Oncological Solutions (TATTOOS) online isotope separation facility, will significantly extend the existing infrastructure. HIMB will provide two orders of magnitude higher muon intensities and TATTOOS unrivalled quantities of a wide range of previously unobtainable radionuclides.

Detailed description
HIMB will boost experimental sensitivity and provide research platforms for a broad national and international user community in particle physics and condensed matter research. A vastly enlarged discovery potential will challenge the Standard Model of particle physics. The UZH center for Detector & Matter at Extremes Test and Research (DEMETER) will develop new instrumentation and establish new technologies for particle detection and sample environments leading to a sea change in muon sciences that will overcome statistical limitations in order to access uncharted parameter space.

The technological developments will bridge to other applications and fields, e.g., sample environments for other large-scale national and international user facilities, and detector applications for high-energy particle physics, photon science, and medical applications. TATTOOS enables global frontline research in radiochemistry, radiopharmacy, and translational nuclear medicine. It will lead to unprecedented production rates of emerging radionuclides for cancer diagnosis and therapy, in particular α-particle emitters, via spallation reactions and isotope mass separation. The facilities at PSI, UZH, and University Hospital Zurich (USZ) will enable radionuclide development, synthesis and preclinical in vitro and in vivo characterisation of novel radiolabeled biomolecules, and the preparation of promising drug candidates according to Good Manufacturing Practice for human application in a «bench-to-bedside» manner. IMPACT is strongly endorsed and supported by a broad community of leading researchers and research collaborations as well as institutions, academic societies, industry, and Swiss hospitals.

b. International level
The High Intensity Proton Accelerator complex (HIPA) at the Paul Scherrer Institute (PSI) hosts the most powerful proton cyclotron worldwide and is among the most energy-efficient accelerators. The enhancements and new opportunities provided by IMPACT excite international partners, as demonstrated by the large number of support letters from three continents. TATTOOS will be an international game-changer in its ability to produce next-generation radionuclides in significant quantities for the development of new cancer diagnostics and therapeutics. HIMB will, amongst other things, benefit international research partnerships in search of new effects beyond the Standard Model of particle physics and novel materials research, thus, enabling Switzerland to continue to play a leading role at the Intensity Frontier in muon physics for many years to come.

c. Development prospects
The core of the IMPACT installation will be located at PSI's HIPA facility. For HIMB, one of the existing target stations with its two connected beamlines will be completely dismantled and rebuilt. The new target station will feature an optimised design to maximise the production of low-energy, positive muons, ideally suited to particle physics and condensed matter research. The DEMETER centre at UZH will boost the research and development capabilities of high-rate-capable pixel detectors and advanced high-pressure sample cells in order to exploit the potential of much higher muon rates. From 2029 onwards, HIMB will provide the most intense, continuous, low-energy surface muon beams for particle physics and

27 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

condensed matter research worldwide for decades to come. TATTOOS will utilise a new beamline that will divert a fraction of the proton beam towards a new building that will host the target and experimental installations, which are planned for completion during 2029-2030. TATTOOS will substantially extend the capabilities that can be extracted from HIPA as a large research facility, thus, enhancing its value for the Swiss and international user base. Radiochemistry and radiopharmaceutical facilities at UZH and USZ will optimally leverage this potential to spur clinical research with novel radiopharmaceuticals for targeted tumour therapy, a rapidly developing field with outstanding potential for personalised medicine. Full user operation for TATTOOS is foreseen from 2031 onwards. In the longer term, researchers far beyond the initial core user groups could benefit from IMPACT, specifically in astrophysics, materials science and radiochemistry. The facility will continuously engage with the research base in order to continue maximising its potential for research and innovation in Switzerland.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	UZH: 1.40	Higher Education Institution:	UZH: 5.80	Higher Education Institution	UZH: 1.50
Canton	0	Canton	0	Canton	0
Swiss Confederation	PSI: 10.50	Swiss Confederation	PSI: 25.80 ETH Board 50.00 SERI[28]: 4.5.00	Swiss Confederation	PSI: 6.90 ETH Board 10.00
Third parties	0.80	Third parties	7.30	Third parties	0.60
Total budget	**12.70**	**Total**	**93.40**	**Total**	**19.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	4.80	Investments	71.90	Investments	10.20
Operating costs	0.20	Operating costs	1.50	Operating costs	4.80
Other costs	7.70	Other costs	20.00	Other costs	4.00
Total costs	**12.70**	**Total**	**93.40**	**Total**	**19.00**

Development Phases	**Years**
Design	2022–2023
Preparation	2023–2024
Implementation	HIMB: 2025–2028, TATTOOS: 2026–2030
Operation	HIMB: from 2029, TATTOOS: from 2031

28 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

3. SwissBioData Ecosystem (SBDe)

Category: Information and services infrastructure
Host institution(s): University of Bern and Swiss Institute of Bioinformatics, in collaboration with Universities of Basel, Fribourg, Geneva, Lausanne and Neuchâtel, Università della Svizzera italiana, University of Zurich, SUPSI, HES-SO, EPFL, ETH Zurich, PSI, SIAF, Agroscope, FMI and Switch
Main funding sources: Structural funds by participating universities and institutions; competitive funds; user fees; Swiss Confederation (SERI)[29]
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
In recent decades, the life sciences have been shaped by new technologies that result in large amounts of data. Switzerland is at the forefront of this data revolution. To support this transformation, research institutes have invested massively in local data-generating and data-processing platforms and embraced open research data principles. However, effective data sharing and reuse require the adoption of shared quality and operational standards and close collaboration between domain experts and data scientists.

The SwissBioData ecosystem (SBDe), a decentralised infrastructure, addresses these challenges and boosts Switzerland's capacity to convert research data into knowledge and innovation. The SBDe aims to: i) increase quality, standardisation, and efficiency across the data value chain – from data production to knowledge generation – through platform federation; ii) provide state-of-the-art support to the Swiss research community to make their data, methods, software tools, and workflow FAIR (findable, accessible, interoperable, reusable); and iii) establish new resources that will reinforce Switzerland's international competitiveness and standing in data infrastructure for life sciences.

Detailed description
The IT infrastructures and research platforms at Swiss institutions currently serve mainly their local research communities and are largely disconnected from each other. Consequently, there are similar infrastructures throughout Switzerland that could be used more economically if they were interconnected. The SBDe strives to avoid duplicating efforts and to leverage existing infrastructures and initiatives through better coordination across the national as well as international data science ecosystem. SBDe is structured in four main pillars:

(i) Production: SBDe harmonises best practices for data acquisition, implementation of quality control strategies, analysis and constant updating of the data format and metadata landscape across 54 core facilities, platforms, and research groups from 18 Swiss institutions.
(ii) Analysis: SBDe supports FAIR data processing, analysis and predictive modelling by helping researchers to build, adapt and deploy software tools and workflows on distributed computing infrastructures; providing expert level support to aid researchers in all steps of their data processing and analysis; promoting software components' reuse through maintenance, documentation, and training; and supporting standardisation, deployment and sharing of trained machine learning models.
(iii) Integration: SBDe experts help researchers to structure, describe, and share data to maximise FAIR prospects and to automate data query and integration procedures. The new resource SwissBioData Knowledge Graph (SBD-KG) connects related datasets scattered across different repositories and includes both metadata and ontologies to establish semantic interoperability.
(iv) Cloud services: SBDe services and resources rely on an interoperable technology layer. Using virtualisation technologies, SBDe supports federated data processing, combining local infrastructure with computational resources available on external clouds.

b. International level
SBDe will boost Switzerland's international visibility in the field of data science, thereby making Switzerland attractive for researchers from all around the world. International researchers may participate in collaborative research projects together with national partners to use and improve SBDe's infrastructure. SBDe can be used by all international researchers without an ongoing collaboration, provided that the usage costs are covered. Any

29 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

new data resources developed during the project which are of interest to the international research community, will be integrated into the SIB resource portfolio and will be available to national and international researchers.

c. Development prospects

SBDe's focus in the implementation phase is to establish the necessary infrastructure and expertise on national level by federating data production platforms, data reservoirs and computing resources, and by leveraging the 54 core facilities, platforms, and research groups. SBDe's activities in these areas will promote collaborations between researchers from different institutions. This will help to attract more funding, create synergies between core facilities/platforms and support cutting-edge life science research. In the operation phase, SBDe will continue to push the digital transformation process of the data-driven life sciences and expand the reach and visibility to institutions and researchers beyond Switzerland. Importantly, continued investment, adaptation to new technologies and methodologies, and alignment with the community's needs will be crucial to sustainable success for SBDe.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution		Higher Education Institution		Higher Education Institution	
Universities	0.39	Universities:	24.16	Universities:	20.62
ETH Domain[30]	0.03	ETH Domain[31]:	3.41	ETH Domain[32]:	3.41
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation		Swiss Confederation	
		SERI[33]:	24.16	ETH Domain:	3.41
		ETH Domain:	3.41	Art. 15 RIPA[35]:	11.58
		Art. 15 RIPA[34]:	11.58	other Institutions:	4.90
		other Institutions:	4.9		
Third parties		Third parties		Third parties	
other institutions	0.66	user fees:	12.46	user fees:	24.92
		other matching funds:	6.64	other matching funds:	6.64
				tbd:	20.60
Total budget	**1.08**	**Total**	**90.72**	**Total**	**96.08**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	0.80	Investments	0.8
Operating costs	0.94	Operating costs	78.09	Operating costs	82.75
Other costs	0.14	Other costs	11.83	Other costs	12.53
Total costs	**1.08**	**Total**	**90.72**	**Total**	**96.08**

Development Phases	**Years**
Design	2021–2022
Preparation	2023–2024
Implementation	2025–2028
Operation	2029–2032

30 In kind contributions
31 In kind contributions
32 In kind contributions
33 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.
34 Application for support through Art. 15 RIPA (Federal Act on the Promotion of Research and Innovation) due in June 2023 with decision end of 2024.
35 Application for support through Art. 15 RIPA (Federal Act on the Promotion of Research and Innovation) due in June 2027 with decision end of 2028.

4. Swiss Data Science Center+ (SDSC+)

Category: Information and Service Infrastructure
Host institution(s): EPFL, ETH Zurich, PSI
Main funding sources: ETH Board + third-party
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
To specifically address the rapidly growing demand for scientific services in Data Science & AI, and in an effort to consolidate existing talents and resources, and avoid fragmentation, we propose to significantly scale up the SDSC into a decentralised national infrastructure with a dedicated governance model.

We envision an infrastructure that would provide both a standardised offering through its core services in data and data science (horizontals) and community-tailored services and know-how via its domain-specific pillars (verticals). It would offer access to harmonised data and curated data-driven science in application domains, with a full-fledged research collaboration and education platform for scientists and field experts, thereby strengthening its position as a trusted partner for data and associated services nationwide and beyond.

Detailed description
The SDSC has developed into a leading Data Science and AI player in Switzerland, with a quantifiable impact on academia and industry. Though the achievements described above are promising, Switzerland is still working towards progressively becoming a leading country in the field of Data Science and AI. Since the beginning, we have witnessed rapidly rising demand for the expertise and services provided by the SDSC. There is a resounding need for a large applied research infrastructure embracing collaborations nationwide – beyond the ETH Domain – and pooling resources from Swiss higher education institutions.

Building on the success of the SDSC, we propose to expand its reach to establish a Swiss-wide scientific service platform open to the entire Swiss community including academia, industry and administration. This new research infrastructure, tentatively named SDSC+, will be composed of core services (horizontals), which provide standard services to users independent of their disciplines; i.e., a one-stop shop for data collection, data management and curation services, and for technical and scientific support in data science and AI. They serve as the basis for community-specific features (verticals) which offer skills and services tailored to the community's needs and requirements).

The governance of SDSC+ will be based on the well-established model of the SDSC and will enable a natural integration of communities by involving them in the steering of their vertical and being represented in the Steering Committee. The organisation of SDSC+ by horizontals and verticals is agile, simple, and enables scalability to include additional areas such as radioastronomy and cosmology. Each vertical will involve all relevant stakeholders and have one representative on the Steering Committee. This is to ensure that SDSC+'s offering is always aligned to its broad community of users.

b. International level
SDSC+ will explore and develop potential partnerships with similar efforts abroad.

c. Development prospects
New verticals can be added and docked to the existing core services depending on needs. Periodic evaluation will be performed to identify if there is an interest in offering domain-specific services to all scientific disciplines (i.e., making domain-specific services part of the core services).

In addition, community-tailored core services will be offered to embrace the specificities of an entire field. For instance, the handling of biomedical data requires stringent security and privacy parameters which should be offered to all users within the AI Health and Medicine vertical. As such, it constitutes a core horizontal service to this community. Another example of a core service to the biomedical community is custom analyses for genomics and proteomics data, from data clean-up to differential expression analysis to biomarker selection.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	0
Canton	0	Canton	0	Canton	0
Swiss Confederation	ETH Board 45.00	Swiss Confederation	ETH Board 60.00	Swiss Confederation	ETH Board 100.00
Third parties	14.00	Third parties	20.00	Third parties	34.00
Total budget	**59.00**	**Total**	**80.00**	**Total**	**134.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	0	Investments	0
Operating costs	59.00	Operating costs	80.00	Operating costs	134.00
Other costs	0	Other costs	0	Other costs	0
Total costs	**59.00**	**Total**	**80.00**	**Total**	**134.00**

Development Phases	Years
Design	2024–2025
Preparation	2025–2028
Implementation	2025–2028
Operation	2021–2032

5. Swiss Institute for Drug and Device Development (SI3D)

Category: Technical and Service Infrastructure
Host institution(s): University of Zurich
Main funding sources: University of Zurich, user fees, private sector
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
New medical or veterinary therapies must undergo challenging regulatory approval processes which constitute almost insurmountable obstacles for most academic research groups. The proposed Swiss Institute for Drug and Device Development (SI3D) will extend the academic R&D pipelines to product development. It will unify all required compliance monitoring programmes (GLP, GMP, and GCP: GxP for short) in a modular research and coordination platform. This centralised platform, built on cutting-edge certified infrastructure, providing advanced technologies and skilled personnel, will be instrumental in driving academic biomedical discovery and innovation in Switzerland. SI3D will define the state of the art for animal experiments essential for medical and veterinary research, and will provide academia and industry partners alike with a regulated, quality-controlled biomedical R&D environment. This will support Swiss academia and industry to develop new therapies for humans and animals.

Detailed description
During the last two decades, various academic institutions in Switzerland have begun to assist academic researchers with GxP platforms to support bench-to-bedside projects. However, no single research department provides all the required competencies, facilities, and quality management systems. To address this fractionated status, we propose to establish the SI3D at the national level. SI3D will provide a scalable, one-stop solution for basic and clinical researchers to drive biomedical inventions from the bench to the bedside. SI3D will bundle existing individual academic GxP service units, thereby bringing together decades of complementary experience and know-how in advanced preclinical and clinical research (i.e. testing and development of drugs and medical devices). These activities will then be supplemented with newly established GxP services (e.g. nonhuman primate services, animal genetics, clinical veterinary and pathology services, veterinary clinical studies services, and data services). Anchoring preclinical in vivo research and clinical research on animals at the Vetsuisse Faculty will significantly increase the credibility and validity of experimental models. Collaboration between human and veterinary medicine will lead to strong synergies that benefit human and animal patients. In addition, collections of patient samples and data will be in compliance with Swiss, EU, and international data protection practices and GxP regulations to facilitate international regulatory approval and fast market entry for new drugs and medical devices.

SI3D will primarily support academic projects and academic–industry partnerships. It will, however, also be open to industry partners. Selection criteria for approved projects will include development stage, feasibility, type of product or device, regulatory framework, and intellectual property status. With this selection and evaluation procedure, the SI3D ensures optimal use of its resources. The next generation of scientists will acquire GxP expertise at Master's, PhD, and professional levels.

b. International level
SI3D will be the Swiss academic centre for translational research in veterinary and human medicine. Thus, it will serve as a platform for international collaborations and provide an ideal complement to the European ESFRI ecosystem (e.g., EU_IBISBA proposal). In addition, SI3D will become a strong and attractive partner for international consortia (e.g., EU networks). The activities of SI3D will be compliant with the regulations not only of Swissmedic, but also of the EMA and the US FDA.

As a strong national infrastructure, it will set a new standard and become a significant node in European networks and beyond. Nationally and internationally, this proposed transdisciplinary research infrastructure will become a world-class beacon for researchers from academia and industry alike.

c. Development prospects
The mission of SI3D is to drive biomedical discovery and innovation by providing a state-of-the-art, quality-controlled, best-practice research and development environment. It will follow the highest ethical standards. To achieve its goals, SI3D will foster fruitful interaction

between its experts and researchers. SI3D will thoroughly evaluate the scientific foundation of a translational research project and strengthen the project's plans, resulting in a faster and more successful market entry. By their direct exposure to the needs of the research community, the staff of SI3D will continually improve their services and expand their expertise in the application of GxP processes.

SI3D will gain international visibility for its preclinical development and animal research expertise. Its services will be combined to facilitate preclinical in vitro and in vivo development for advanced medicinal products and medical devices for humans, firmly placing Switzerland on the map for this type of «One Health» approach to medicine. During the initial phase, existing expertise and infrastructure will be consolidated and SI3D will be connected to other relevant professional networks in Switzerland. In the second phase, the SI3D infrastructure and expertise will be expanded. This expansion will follow the requirements from a research and regulatory standpoint, the latter of which will be continually monitored as it evolves. The modular structure of SI3D with its GxP platforms will facilitate stepwise improvements.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	University of Zurich: 10.10 University Hospital Zurich, Universities of Bern and Fribourg: 3.60	Higher Education Institution	University of Zurich: 32.40 University Hospital Zurich, Universities of Bern and Fribourg: 3.60	Higher Education Institution	University of Zurich: 32.40 University Hospital Zurich, Universities of Bern and Fribourg: 3.60
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	SERI[36]: 19.90	Swiss Confederation	0
Third parties	SNSF/EU: 1.20 Private sector: 3.90 User fees: 5.80	Third parties	SNSF/EU: 1.20 Private sector: 4.10 User fees: 7.00	Third parties	SNSF/EU: 1.20 Private sector: 4.10 User fees: 7.20
Total budget	**24.60**	**Total**	**68.20**	**Total**	**48.50**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	5.30	Investments	19.90	Investments	0
Operating costs	13.40	Operating costs	33.40	Operating costs	32.90
Other costs	5.90	Other costs	14.90	Other costs	15.70
Total costs	**24.60**	**Total**	**68.20**	**Total**	**48.50**

Development Phases	**Years**
Design	2020–2022
Preparation	2022–2026
Implementation	2025–2028
Operation	From 2027

36 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

6. EM-Frontiers

Category: Instruments
Host institution(s): Empa, EPFL, ETHZ, PSI, UniBE, UniGE, UniL, UNIBAS, UZH
Main funding sources: ETH Board, Swiss Confederation (SERI)[37], UniBE, UniGE, UniL
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
Electron microscopy (EM) is one of the most powerful methods for studying the structure and interactions of atoms, molecules and materials, and is a major driving force in scientific and applied research. Up until now, advancing the capabilities of EM was mainly driven by individual research groups. Though this has delivered major successes in the past, pushing the technological envelope will increasingly require coordination between disciplines and research facilities.

EM-Frontiers will support key technology platforms and advanced instrumentation, inviting for cross-disciplinary collaborations. It will serve as an open-access facility for the analysis of life sciences and physical sciences specimens.

Detailed description
Electron microscopy (EM) has revolutionised our understanding of materials and biology, driving transformative discoveries across natural sciences. Recent advancements in electron optics, detectors and data science have made EM the gateway to boosting fundamental atomistic understanding of life and physical sciences. EM will thus play a key role in tackling pressing societal needs related to health, sustainability, energy and climate.

EM-Frontiers will create a national research infrastructure distributed across ETH Domain institutes and the DCI (Dubochet Center for Imaging). It will synergise existing expertise, fostering methods development and research that would not be possible for any of the institutions alone.

EM-Frontiers will exploit the dimensions of EM. In the life sciences, proteins are investigated by cryo-electron microscopy and diffractive imaging techniques. Larger protein targets in their cellular context can be investigated by cryo-electron tomography and in correlation with light and X-ray imaging techniques. Small inorganic and organic crystals, crucial for catalysis, functional materials and energy research, are characterised by electron diffraction and diffractive imaging techniques. Dynamic processes are followed in time. Liquid samples of battery material and heterogeneous catalysts are studied to understand their structure and behaviour under real-world conditions. And a multi-scale approach for in-situ / operando EM observation of functional materials under relevant conditions is applied in the context of energy and sustainability research.

EM-Frontiers will bridge complementary expertise from the participating laboratories. The combination of life and physical sciences EM expertise will allow new approaches to the study of biological systems at high spatial and/or temporal resolution, also in a cellular or multicellular context. Physical systems will be accessible in 3D at high sensitivity. EM-Frontiers will collaborate with data processing centres throughout Switzerland to harvest algorithmic developments from automation and deep learning.

A central office will streamline access for Swiss and international researchers, and will coordinate research collaborations and the exchange of expertise between participating sites. A Scientific Steering Committee with rotating leadership will direct the activities, and a Scientific Advisory Board will provide expert recommendations.

b. International level
EM-Frontiers will assure the continuation of Switzerland's strong position in electron microscopy, and it will make this technology openly accessible to all Swiss and international researchers from academia and industry through a central proposal submission and reviewing system. It will foster new opportunities for research collaborations across Europe.

c. Development prospects
EM-Frontiers will benefit from multidisciplinary expertise for structural investigations. It will support method

37 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

development by providing access to suitable instrumentation, and by structuring cross-fertilisation and the exchange of knowledge. EM-Frontiers will connect specialised expertise in camera technology, advanced data processing algorithms, time-resolved studies in the milito atto-second regime, highest-resolution imaging, diffractive techniques, automated high-throughput sample preparation, and electron tomography in correlation with light microscopy and X-ray imaging, which are currently only available in isolated locations. The combination of these disciplines will encourage new EM technology development that will be made available to Swiss and international clients as research platforms.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	UNIBE, UNIGE, UNIL: 30.90	Higher Education Institution	UNIBE, UNIGE, UNIL, UNIBAS, UZH: 10.99	Higher Education Institution	tbd
Canton	0	Canton	0	Canton	0
Swiss Confederation	Empa, EPFL, ETHZ, PSI: 46.40	Swiss Confederation	ETH Board: 30 SERI[38]: 10.99	Swiss Confederation	ETH Board: tbd Empa, EPFL, ETHZ, PSI: tbd
Third parties	0	Third parties	User fees: 1.82	Third parties	User fees: tbd
Total budget	**77.30**	**Total**	**53.80**	**Total**	**tbd**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	40.70	Investments	35.90	Investments	13.00
Operating costs	13.70	Operating costs	17.90	Operating costs	17.09
Other costs	Building costs: 23.00	Other costs	0	Other costs	tbd
Total costs	**77.30**	**Total**	**53.80**	**Total**	**tbd**

Development Phases	**Years**
Design	2021–2023
Preparation	2023–2024
Implementation	2024
Operation	2025–2032

38 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

7. Imaging and Omics Platform for Swiss Citizen Health (IOP4CH)

Category: Integrated Research Infrastructure (Citizen Cohort; Biobank; MRI Imaging)
Host institution(s): University of Basel and associated institutes Swiss TPH and Institute of Molecular and Clinical Ophthalmology Basel (IOB), in collaboration with the Universities of Bern, Fribourg, Geneva and Lausanne, Università della Svizzera italiana and the University of Zurich, universities of applied sciences SUPSI, FHNZ and ZHAW, SSPH+, Roche
Main funding sources: Structural and/or in-kind funds from participating universities, SSPH+, and Roche; contribution of existing cohorts (participants/data); Swiss Confederation (SERI)[39]; others tbd
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The overarching goal of IOP4CH is to provide public, environmental, personalised, and digital health research as well as clinical research in Switzerland, with the current lack of Swiss Bio and Swiss Imaging Reference Data that is central to understanding and promoting healthy ageing. Obtaining reference data, images, and biological samples from citizens before they develop one or more diseases is essential for i) primary prevention, to understand mechanisms that accelerate or slow down ageing processes and affect disease risk, ii) secondary prevention, to assess the public health and clinical utility of novel ageing and disease risk prediction and screening approaches that make use of molecular and imaging derived biomarkers, and iii) tertiary prevention, to support clinical research in the discovery of novel diagnostics and interventions with control data. IOP4CH focuses on the pathway from broad external exposome (lifestyle; physico-chemical, built, food, and social environments) to internal exposome (e.g., microbiome, metabolome, transcriptome) and retinal imaging as the "lens" to other organs in the context of multi-organ MRI.

Detailed description
The scalable and nationally governed research infrastructure IOP4CH builds on existing infrastructure and expertise: i) the well-characterised population-based COVCO-Basel cohort of more than 10,000 participants, which is scalable to integrate the Corona Immunitas digital cohort; ii) examination laboratories at Swiss TPH and IOB for health and ophthalmological examinations; iii) scalable biobanking infrastructure at Swiss TPH (–80 °C freezers; liquid nitrogen tanks); iv) long-term cohort and biobanking expertise integrated with expertise network in genomics and meta-genomics, exposome science, ophthalmology, mental health, neurology, radiology, biomedical engineering, drug research, and computational and data science, along with the broad national public health research and training network SSPH+. IOP4CH complements existing infrastructure and expertise with: i) the implementation of MRI infrastructure dedicated to research, ii) deep phenotyping of 10'000 cohort participants and nested longitudinal profiling of 500 participants (digital interviews; sensors/wearables; age-related phenotyping; eye examinations including retinal imaging; MRI imaging of brain, spinal cord, heart, lung, liver, and adipose tissue; biosampling (stool; nasal swabs; urine; blood cells; serum/plasma; DNA); imaging and molecular biomarkers; exposome modelling to address history including residence and work place).

The IOP4CH study protocol will be developed in close collaboration with national and international scientists, consider the Swiss research data needs of academic, policy, and private stakeholders, and aim at harmonisation of study protocols with international cohorts and with relevant Swiss surveys and cohorts. IOP4CH will apply technologies, infrastructures, protocols, and guidelines for data and biomarker collection, processing and storage as developed by other organisations (e.g., the SPHN; Swiss Biobanking Platform). FAIR principles will applied for the study instruments and collected data.

b. International level
International comparison shows that many countries, including members of the EU, are establishing large-scale cohorts with biobanks and integrated smaller deeply phenotyped (including for omics and images) sub-cohorts. IOP4CH will strengthen population health and personalised health sciences in Switzerland by complementing existing research infrastructures, in particular the Swiss Personalized Health Network (SPHN) and the National Coordination Platform Clinical Research (CPCR).

39 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

c. Development prospects

A Swiss Cohort & Biobank of at least 100,000 citizens for research into well-being and non-rare disease pathways and to support the development of evidence-based policy and guidelines is in its planning phase. The need for a healthy population-based reference cohort has been acknowledged in the planning of SPHN. IOP4CH strengthens the plan for a larger cohort by already implementing an SNSF-evaluated North-Western Switzerland hub and by complementing it with the deeply phenotyped sub-cohort that is able to provide Swiss Bio and Swiss Imaging Reference Data.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	10.00	Higher Education Institution	22.95	Higher Education Institution	17.68
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	SERI[40]: 22.95	Swiss Confederation	
Third parties	0	Third parties	0	Third parties Funds for Cohort & Biobank (tbd): 17.68	
Total budget	**10.00**	**Total**	**45.89**	**Total**	**35.36**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	8.65	Investments	0.79
Operating costs	6.66	Operating costs	20.88	Operating costs	20.88
Other costs	3.34	Other costs	16.36	Other costs	13.71
Total costs	**10.00**	**Total**	**45.89**	**Total**	**35.36**

Development Phases	**Years**
Design	2023–2024
Preparation	2023–2024
Implementation	2023–2024
Operation	2025–2032+

40 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

8. Swiss Biosites for Sustainable Agriculture and Agroecology (SISAL)

Category: Integrated Research Infrastructure
Host institution(s): ETH Zurich (lead), Eawag, WSL, Empa, EPFL
Main funding sources: ETH Board, host institutions, third-party
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The Swiss Biosites for Sustainable Agriculture and Agroecology (SISAL), a unique, physical and digital open-access research infrastructure (RI), is a cornerstone to enable the Swiss farming sector to make a successful transition to sustainable food and feed production. SISAL provides i) agroecological RIs, accounting for the heterogeneity in topography, land cover, and land use intensity across Switzerland, ii) cutting-edge experimental facilities equipped with innovative technologies, allowing near-real time assessments of performance and the scaling up of smart solutions in agricultural sciences, and iii) next generation data acquisition, data management, and artificial intelligence-based data evaluation to leverage the adoption of smart and reliable solutions. Thus, SISAL accelerates the transfer of experimental results under the current and future climate situation to the implementation of innovative solutions by land managers, and stakeholders, thereby contributing to several Sustainable Development Goals.

Detailed description
SISAL is composed of five Work Packages: (1) distributed field RI at landscape and ecosystem scales, (2) local field RI at plot scale, (3) mesoscale RI, (4) mobile instrumentation, and a (5) coordination and data platform. SISAL builds on existing agroecological and watershed RI facilities and networks within the ETH Domain, strengthens further nodes of existing networks and better connects them, upgrades their sensor portfolio, and expands their spatial representativeness to account for existing agricultural intensity gradients. Cutting edge research facilities are established and/or upgraded, new methodological approaches such as drone- and robot-based plant and land-surface monitoring are developed and tested under real-farm conditions. A biobank ensures better characterisation and preservation of microbiota and environmental DNA samples from agro-food ecosystems for re-use and re-analysis. Next generation custom-tailored IT solutions for open access data streams, data management, and smart analyses (e.g., with artificial intelligence) are developed in a central data platform, supported by the Swiss Data Science Center. The World Food System Center at ETH Zurich acts as a coordination and dissemination centre.

b. International level
SISAL facilities are part of international infrastructure networks, e.g., the Integrated Carbon Observation System (ICOS) RI and the European infrastructure for multi-scale plant phenomics and simulation EMPHASIS. SISAL also adds to the Global Long-Term Agricultural Experiment Network. Moreover, access to SISAL RI, as well as SISAL data, is granted to academics as well as to public and private stakeholders in Switzerland and beyond.

c. Development prospects
Set-up and installation of the first RIs within SISAL will be finalised in 2025 and 2026, during the first two years of the Implementation Phase. These first SISAL RIs will become operational in 2026, and further upgrades will be implemented so that SISAL will be fully operational by the end of 2028. In 2029, SISAL will enter its Operation Phase, which will run until 2032 and beyond.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	0
Canton	0	Canton	0	Canton	0
Swiss Confederation ETH Board 0 Host Institutions 5.60		Swiss Confederation ETH Board 30.00 Host Institutions 4.40		Swiss Confederation ETH Board 18.20 Host Institutions 3.40	
Third parties	1.60	Third parties	3.50	Third parties	2.60
Total budget	**7.20**	**Total**	**37.90**	**Total**	**24.20**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	3.20	Investments	12.20	Investments	3.20
Operating costs	4.00	Operating costs	21.70	Operating costs	21.00
Other costs	0	Other costs	4.00	Other costs	0
Total costs	**7.20**	**Total**	**37.90**	**Total**	**24.20**

Development Phases	**Years**
Design	2017–2020
Preparation	2021–2024
Implementation	2025–2028
Operation	2029–2032

9. Swiss Quantum Communication Infrastructure (Swiss-QCI)

Category: Technical Infrastructure
Host institution(s): University of Geneva
Main funding sources: Swiss Confederation (SERI)[41], University of Geneva, METAS, University of Bern, private sector.
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The Swiss Quantum Communication Infrastructure (Swiss-QCI) is planned as a distributed fibre-optic network facilitating research in quantum science, in particular quantum communication as well as time and frequency dissemination. It will utilise state-of-the-art equipment and provide a research environment to test next-generation technologies, concepts and applications. The infrastructure will also serve as a flexible educational platform allowing the next generation of scientists and engineers to train in the rapidly emerging quantum technologies domain. It will provide the foundation for developing the security of data communication and storage, as well as critical infrastructures across Switzerland.

Detailed description
The Swiss Quantum Communication Infrastructure (Swiss-QCI) is designed as an open-access environment to facilitate research, from fundamental to applied, across a distributed fibre-optic network spanning Switzerland. This will include around 1,000 km of fibre network between Geneva and Zurich, 20+ quantum key distribution systems, connectivity to time and frequency references at METAS, as well as a telescope upgrade to ensure readiness for satellite communication for all of these activities. Access to the network and deployed systems will allow users to research quantum communication networking in a real (classical network) environment as well as designing, building and validating applications with end-to-end quantum-enabled security.

This would also facilitate connection to the neighbouring German, Italian, Austrian, and French QCI networks as they start to deploy, ensuring that Switzerland does not fall behind or become incompatible with progress across Europe. This aims to ensure the future security and quantum-readiness of Europe-wide data communication, storage and network application. The addition of a satellite-capable telescope to the network, dedicated to establishing optical links from ground to space, also ensures Switzerland's readiness and capability to participate in future global quantum communication missions. This will become increasingly important in the next few years as more quantum-enabled satellites are launched – not only for quantum communication, but also for fundamental science that increasingly requires optical links (high data rate communication; high accuracy, resilient and synchronous time and frequency transfer). The inclusion of time and frequency distribution in the Swiss-QCI follows a similar approach to that being taken across Europe for the EuroQCI, as well as other international initiatives such as metrology; thus we hope to ensure forward-compatibility such that these different networks could be connected.

The Swiss-QCI will provide a focal point not only for research, but also training and innovation activities that do not yet exist in Switzerland.

b. International level
The Swiss-QCI represents a unique opportunity to realise a world-class research infrastructure in Switzerland, facilitating not only fundamental and applied research but spanning myriad application areas from quantum communication to sensing and metrology. This would mirror similar initiatives being launched around the world, including in Europe, and would enhance our long-term competitiveness and compatibility for the deployment and exploitation of quantum technologies across fibre, and even satellite, communication networks. It would also lay the foundation for training the next generation of scientists and engineers in this rapidly emerging domain. The Swiss-QCI is designed as an open platform and will also be open to Swiss academic institutions and industries. International participation and exchange with other leading centres would also be welcome in order to advance the state of the art in quantum technologies.

c. Development prospects
The Swiss-QCI aims to provide a research environment for all network-based quantum technology research, device and application development, and education and

41 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

training. We have included key experts and institutions from across the country and will continue to grow this community and build a supportive ecosystem. It will build on testbed networks for quantum communication in Geneva and frequency dissemination between METAS, the University of Basel and ETH Zurich. It will already be partially operational in 2025, and the complexity and functionality of the network will subsequently be expanded. It is expected to be fully operational by 2027. The aim is for open access for Swiss researchers, with pay-per-use access to be developed with industry and government agencies as well as international researchers. The aim is to develop these to allow for a transition to a sustainable model for long-term exploitation.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	3.54	Higher Education Institution	tbd
Canton	0	Canton	0	Canton	tbd
Swiss Confederation	0	Swiss Confederation	SERI[42]: 12.19	Swiss Confederation	tbd
Third parties	0	Third parties	9.04	Third parties	tbd
Total budget	**0**	**Total**	**24.77**	**Total**	**tbd**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	18.33	Investments	tbd
Operating costs	0	Operating costs	6.37	Operating costs	tbd
Other costs	0	Other costs	0.07	Other costs	tbd
Total costs	**0**	**Total**	**24.77**	**Total**	**tbd**

Development Phases	**Years**
Design	2023–2024
Preparation	2024–2025
Implementation	2025–2026
Operation	2025–2028

42 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

10. Swiss Fusion Hub

Category: Instruments
Host institution(s): Ecole polytechnique fédérale de Lausanne, Paul Scherrer Institut
Main funding sources: ETH domain, SNSF, SERI (or EURATOM in case of association of CH)
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Swiss Plasma Centre (SPC) was created to catalyse plasma and fusion investigations in Switzerland through the 2017-20 ERI funds. These funds contributed to making TCV *(Tokamak à Configuration Variable)* a shared facility, increase its impact and successfully start new activities in plasma biology and industrial applications. Bringing the role of Switzerland to the next level, we propose further substantial upgrades to TCV and to rebuild the coil of the EDIPO test facility. The infrastructure upgrades we propose leverage the key competencies of the SPC, including its long-lasting leading role in the optimisation of the core plasma, the extensive high-impact recent investigations of advanced boundary plasma geometries, its world-renowned expertise in theory and modelling and the 30-year experience in superconductor testing on the SULTAN facility.

Detailed description
Fusion energy requires high plasma performance, e.g. in terms of temperature and pressure, compatible with the limits imposed by the materials, possibly exploiting high-field and high-current superconducting magnets. TCV's uniquely flexible experimental facility combined with the proposed upgrades will allow us to support ITER operation and guide the design of DEMO. For instance, it will allow for the rapid development of the scientific basis of high-performance core plasmas, including emerging ones based on innovative plasma shapes. This will be integrated with novel solutions to the outstanding challenge of heat exhaust, such as the so-called long-legged, tightly baffled divertor, predicted to increase power handling capabilities by factors of up to five, with no significant increase in the engineering complexity. Tight baffling will be achieved with removable wall structures inside TCV (CHF~0.75m) to experimentally test and optimise the concept. Dedicated instrumentation, including spectroscopic imaging apparatus, will be developed to diagnose such divertors and demonstrate real-time control capabilities (CHF ~0.75m). Additional heating power will be installed to test the concept in reactor-relevant, extreme conditions (CHF~3.5m). In a second step, these solutions will be fully integrated with conventional and novel core plasma solutions (CHF~2m).

Along a different technological avenue, yet just as important as plasma physics for the development of fusion, the EDIPO facility (CHF~5.5m) will become a new world leader in high-field, high-current tests over the coming decades. Leveraging the existing cryoplant, power supplies, control system and vacuum vessel with a new set of coils, replacing those damaged in 2016, the new EDIPO will outperform SULTAN and old EDIPO facilities, allowing for background magnetic fields up to 15 T (in comparison to 10.9 T in SULTAN and 12.3 T in old EDIPO) and a large aperture (144×144 mm^2) to test prototype conductors for fusion and insert coils for accelerator magnets. The construction of the new EDIPO coil will in itself be a cutting-edge project, since the enormous forces (~16 MN/m) impose novel technological approaches that avoid performance degradation during the many years of foreseen operation, and the large aperture requires a compact, accelerator-like winding pack in a liquid helium bath.

b. International level
As the ITER construction is proceeding swiftly towards completion, with the first plasmas expected in a few years, the fusion community has started planning the step beyond ITER; the first prototype reactor DEMO. While ITER will demonstrate the feasibility of fusion energy, DEMO will operate at considerably higher power and gain, and provide net electricity to the grid. We will create the Swiss Fusion Hub within the Swiss Plasma Center by substantially upgrading its infrastructures. The Swiss Fusion Hub will address some of the main physics and technology challenges that remain on the way to fusion energy, supporting the ITER operation and the design of DEMO. We will upgrade the uniquely flexible TCV tokamak facility to establish the physics basis of innovative ideas for controlling heat exhaust and its integration with novel high-performance core plasma scenarios. We will build an upgraded version of the superconducting coil of the EDIPO test facility, which will

provide a worldwide unique test bed for the best performing superconducting cables for fusion magnets. Our activities will also impact other fields, for instance the development of particle accelerators. It should be noted that the development and procurement of an additional plasma heating system based on advanced microwave technology will serve to strengthen industrial policy for fusion at a European level, as well as technology transfer and spin-offs in Switzerland.

c. Development prospects

Nuclear fusion is a prime source of future, clean and sustainable base load energy production, required in a carbon-free energy mix, relying heavily on intermittent renewable energy sources. In addition to fusion, the new EDIPO will be used for testing high-field insert coils for accelerator magnets and other applications, e.g. for superconducting high-field research facilities (e.g. High Field Magnet Laboratory in the Netherlands). This will make Switzerland one of the European hubs for the development of the physics and technology know-how necessary to achieve fusion energy, securing its position for continued, high-impact contributions to the international fusion effort, also in view of the upcoming European fusion facility review in 2023.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	0
Canton	0	Canton	0	Canton	0
Swiss Confederation	EPFL 8.50, PSI 2.00	Swiss Confederation	ETH Board 12.50 EPFL 4.80, PSI 2.00	Swiss Confederation	EPFL 6.00, PSI 2.00
Third parties	EURATOM/SERI 7.50	Third parties	EURATOM/SERI 4.00, EDIPO users 1.00	Third parties	EURATOM/SERI 4.00., EDIPO users 4.00
Total budget	**18.00**	**Total**	**24.30**	**Total**	**16.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	2.00	Investments	12.50	Investments	4.00
Operating costs	8.00	Operating costs	8.00	Operating costs	12.00
Other costs	8.00	Other costs	3.8.0	Other costs	0
Total costs	**18.00**	**Total**	**24.30**	**Total**	**16.00**

Development Phases	**Years**
Design	2021–2023
Preparation	2024
Implementation	2025–2028
Operation	2029ff

11. A Swiss Geo-Time Research Infrastructure (Geo-Time)

Category: Technical Infrastructure
Host institution(s): Universities of Lausanne, Geneva and Bern, EPFL, ETH Zurich
Main funding sources: Universities of Lausanne, Geneva and Bern, Swiss Confederation (SERI)[43], SNF/EU
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The Swiss Geo-Time research platform (Geo-Time) is a distributed research infrastructure that unites national (SwissSIMS) and singlesite laboratories at the Universities of Lausanne, Geneva and Bern, EPFL and ETH Zurich. The tight integration of state-of-the-art instrumentation will mark the beginning of a new coordinated national effort to study the duration and rates of geological and environmental processes. It includes cutting-edge instruments and instrument development delivering world class data and science output. Geo-Time will develop a cyber-infrastructure for rapid and user-friendly data handling, meeting the requirements of the FAIR data principle and committed to fully open access of scientific output and data.

Detailed description
The Swiss Geo-Time research infrastructure (Geo-Time) will federate and develop the following analysis facilities and components: high spatial resolution and highest precision mass spectrometers that measure elemental and isotopic ratios of materials relevant to the Earth sciences, with applications in environmental and life science. Complementary instruments comprise secondary ion mass spectrometry (SwissSIMS, Cryo-NanoSIMS, chemical abrasion thermal ionisation mass spectrometry (CA-TIMS), and laser ablation (multi-collector) inductively coupled plasma mass spectrometry (LA-(MC)-ICP-MS). Additional instruments providing improved capabilities of element mapping, such as scanning electron microscopy (SEM), field-emission gun electron microprobe (FEG-EPMA), and Cryo-SEM combined with the highest resolution in-situ mass spectrometry will uniquely contribute constraints on the absolute timing and rates of geological and environmental processes throughout Earth's history. Data acquisition, reproducibility and quality control will be enabled through standardised software use and measurement protocols. The cyber infrastructure will be based on existing data centres in the distributed facilities, tailored to support Geo-Time data storage and processing, including metadata. These will be key to maximi the scientific impact of Geo-Times through open data access.

With the planned implementation of the Geo-Time infrastructure between 2025 and 2028, the facilities will be complemented with an ultra-high precision and higher yield thermal ionisation source mass spectrometer (TIMS) with novel collector technology; a custom-built secondary ionisation mass spectrometer (SIMS) with a new plasma source currently being developed in the Swiss Plasma Center at EPFL; multi-collector and laser ablation inductively coupled plasma mass spectrometers with collision/reaction cell interface to reduce isotopic interferences and matrix effects (LA-MC-ICP-MS/MS); and an in-situ high-sensitivity noble gas isotope ratio mass spectrometer. Installation of the instruments is expected in 2025 – 2026, facilitating data collection for the core investigators (University of Lausanne, University of Geneva, University of Bern, EPFL and ETH Zurich), and expanding to other interested investigators and institutions thereafter.

b. International level
Geo-Time will be unique in its setting. There are several international key infrastructures related to the quantification of the duration and rates of Earth processes. However, very few have the combination of large-radius ion microprobes (SwissSIMS, NanoSIMS and the recently developed CryoNanoSIMS, with the highest spatial resolution), chemical abrasion TIMS for highest precision and expertise in imaging, petrochronology and the development of novel dating techniques.

c. Development prospects
The Geo-Time facility brings the existing network of labs related to geochronology and isotope geochemistry under a federal umbrella and an efficient governance that will oversee the optimisation of resources and foster national and international collaboration and innovation. It will guarantee coordinated access to the unique

43 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

world-class facilities of the participating institutions, provide education for the next generation of geoscientists and enable new technological developments in collaboration with solid-state physics and material sciences. This facility combines existing laboratories with investment in novel instrumentation that stems from innovation in geochronology and isotope geochemistry techniques. The concerted efforts to use geochronology techniques efficiently in a distributed national facility is a novel concept for the Swiss Earth science landscape and will be attractive to international users. Beyond 2029, we expect that the cost of running the Geo-Time infrastructure will be covered in part on a pay-per-use basis.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	UNIL, UNIGE, UniBe: 3.13	Higher Education Institution	UNIL, UNIGE, UniBe: 13.51	Higher Education Institution	UNIL, UNIGE, UniBe, 4.71
Canton	0	Canton	0	Canton	0
Swiss Confederation	EPFL: 0.63	Swiss Confederation	SERI[44]: 6.76 EPFL, ETH Zurich: 2.11	Swiss Confederation	EPFL, ETH Zurich: 1.01
Third parties	SNSF: 1.70 Foundations 0.33	Third parties	0	Third parties	tbd. SNF, EU 1.60
Total budget	**5.79**	**Total**	**22.38**	**Total**	**7.32**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	3.70	Investments	14.56	Investments	1.60
Operating costs	2.09	Operating costs	5.72	Operating costs	5.72
Other costs	0	Other costs	2.10	Other costs	0
Total costs	**5.79**	**Total**	**22.38**	**Total**	**7.32**

Development Phases	**Years**
Design	2021–2024
Preparation	2023–2026
Implementation	2025–2028
Operation	2027–2036

44 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

12. Swiss Digital Pathology Initiative (SDPI)

Category: National Research Infrastructure
Host institution(s): University of Zurich (consortium lead); Universities of Zurich, Bern, Basel, Geneva, Lausanne (consortium members)
Main funding sources: Universities of Zurich, Bern, Basel, Geneva, Lausanne
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
Precision medicine is entering a new era of digital diagnostics. Digital pathology (DP) captures essential diagnostic, prognostic and predictive information on human diseases, and is emerging globally as a new technology standard. The availability of integrated DP and clinical datasets is a key catalyst for biomedical research, education and industry development. National programmes for standardised generation and sharing of this data are crucial for the development, testing, and validation of machine learning-enabled tools supporting clinical decision-making. The Swiss Digital Pathology Initiative (SDPI) is a joint research infrastructure of the Universities of Zurich, Basel, Bern, Lausanne and Geneva that will enable the digitisation of pathology slides and their computer-aided analysis using computer algorithms, in particular new AI-based solutions. SDPI intends to develop a unique national network of university, cantonal and private hospitals to realise DP's potential for research and clinical workflows. This will bring Switzerland to the forefront of biomedical research in the digital era.

Detailed description
Background: Digital pathology (DP) represents a major inflection point for both research and clinical workflows. In 2019, the European Union approved the use of whole slide scans for primary diagnosis. Research and development by Swiss universities, industry and cantonal institutions have shown in a multitude of research studies that DP images can be analysed by computer algorithms to enable i) more precise characterisation of disease presentation features, and ii) discovery of clinically relevant biomarkers. By supplying improved diagnosis, prognosis, and therapy response predictions, DP is staged to significantly contribute towards the goal of precision medicine. DP approaches benefit from being orders of magnitude faster and more cost-effective than their genetic assay-based counterparts, enabling real-time diagnostic support in clinical practice. Additionally, they are tissue non-destructive, facilitating longitudinal studies of algorithm improvement as disease understanding grows. While the Swiss Personalized Health Network (SPHN) has made significant progress towards developing infrastructures that facilitate access to health-relevant data in Switzerland, there is currently no Swiss-based research infrastructure (RI) that meets the national need for a DP research repository to support basic, translational and clinical research.

Objectives: Via 5 work packages (WPs), the SDPI RI sees the development of a unified national DP network geared towards providing complementary cleaned and coded pathology data to the SPHN, leveraging existing BioMedIT infrastructure. WP1 will establish the SDPI Governance and Management Structure. WP2 will establish SDPI in line with FAIR principles (findability, accessibility, interoperability, reusability), enabling integration of pathology data with SPHN clinical data sets at the partner hospital's Research Data Service Center (RDSC). WP3 will establish and maintain SDPI data storage on the BioMedIT network, WP4 will establish a centralised registry enabling researcher-initiated DP data queries and instantiation of research cohorts supported by annotation tools and data analysis capabilities. WP5 will develop and deliver the SDPI sustainability plan.

Expected results: SDPI will generate a digital repository starting with 1 million slides collected from 2025 to 2028 and will continue to grow at a rate of 100,000 samples per year. This RI will make digital image data from human and animal samples representing common and rare cancers as well as inflammatory, infectious, and degenerative diseases accessible to researchers across Switzerland.

b. International level
DP for Switzerland is of central strategic importance, and in line with the country's large vested inter-ests in personalised medicine. DP represents a synergistic and complementary component to the clinical datasets collected by the SPHN and will strengthen academic research and industry development by providing a more comprehensive understanding of human disease. This will lead to

greater research insights, impactful economic development opportunities, and better patient care. SDPI competitively compares with recent European investments by the United Kingdom (PathLAKE), Germany (EMPAIA), Sweden (PALGA), and the Netherlands (Pathology Image Exchange). With the global DP market expected to reach USD 8bn by 2023, these national investments have already proven fruitful in terms of improved patient care, intellectual property generation, education, employment, establishment of start-up companies, and awarding of competitive EU grants. SDPI seeks to leverage extensive experiences gathered by these initiatives via our established collaborations, thus aiming to improve SDPI instantiation efficiency based on best practices. By establishing SDPI, Switzerland becomes a viable partner for international collaborations at the forefront of biomedical research.

c. Development prospects

SDPI will organically facilitate i) the expansion of the existing SPHN datasets by cleaned and coded DP data, ii) the instantiation of large multi-site patient cohorts for translational biomedical research and clinical trials, iii) the development and implementation of tools for increased diagnostic efficiency, quality and patient safety, and will iv) support the development and utilisation of AI solutions in health sciences for improved patient diagnosis, prognosis, and therapy response prediction. SDPI will be instantiated by a consortium consisting of all five Swiss university hospitals, the Vetsuisse and key national and international stakeholders from academia, research, and industry. SDPI is thus uniquely situated to provide biomedical researchers across Switzerland with access to research data and cutting-edge technology.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution University of Zurich: 0.68 Universities of Bern, Basel, Lausanne, Geneva: 0.67		Higher Education Institution University of Zurich: 2.35 Universities of Bern, Basel, Lausanne, Geneva: 6.76		Higher Education Institution University of Zurich: 1.11 Universities of Bern, Basel, Lausanne, Geneva: 3.01	
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation SERI[45]: 9.11		Swiss Confederation	0
Third parties	0	Third parties SNFS/EU/private sector: 0.20		Third parties SNFS/EU/private sector: 3.00	
Total budget	**1.35**	**Total**	**18.42**	**Total**	**7.12**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	6.82	Investments	2.00
Operating costs	1.35	Operating costs	11.40	Operating costs	4.92
Other costs	0	Other costs	0.20	Other costs	0.20
Total costs	**1.35**	**Total**	**18.42**	**Total**	**7.12**

Development Phases	**Years**
Design	2023–2024
Preparation	2024–2025
Implementation	2025–2028
Operation	From 2028

45 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

13. Operating Room-X (OR-X): A Translational Hub for Surgical Research and Innovation

Category: Instruments, Information and service infrastructure, Technical infrastructure
Host institution(s): University of Zurich
Main funding sources: Balgrist University Hospital, University of Zurich
Roadmap entry: 2023

Description / Development prospects
a. National level
Overview
The Operating Room X (OR-X) provides an optimal and adaptable environment for research, development and implementation of surgical innovations and technologies in Switzerland. The OR-X consists of a fully equipped ex vivo operating theatre – the surgical core facility – and three scalable and future-oriented technological units that will tackle the major challenges of the increasing digitalisation of surgical care. Taking cutting-edge technologies from key research fields and integrating them to create a highly realistic surgical environment is unique for Switzerland. The operational concept of the OR-X pursues a sweeping open access policy for research data and results as well as infrastructure, which strongly fosters national and international collaboration with academia and industry.

Detailed description
The OR-X consists of a four-tier infrastructure and research concept. Tier one is the surgical core facility, which has been fully funded and was newly constructed between fall 2021 and spring 2023. Its centerpiece is a medical-grade research operating room where whole ex-vivo surgeries can be performed on human tissue models. Adjacent is an equally well-equipped surgical laboratory with five surgical workstations where larger experiments or surgical skills training can be carried out. Surgical support infrastructure consists of facilities for the management and storage of surgical instruments, equipment, and human cadavers.

The requested funding is intended to support the implementation of the three technological units, which are represented by tiers two through four. The Unit for Intraoperative Imaging combines state-of-the-art intraoperative imaging technologies with robots (robotic ultrasound, robotic computed tomography) and new sensor technologies (depth sensors, hyperspectral imaging, photogrammetry), allowing researchers to exploit the full potential of intraoperative imaging and develop advanced image-based methods for intraoperative decision-making and error prevention. The Unit for Surgical Data Science connects the OR-X through a high-performance computational network and server infrastructure (Nvidia DGX server infrastructure) for real-time collection and artificial-intelligence processing of surgical data. The Unit for Surgical Execution leverages computer-aided surgery equipment (tracking systems, augmented reality, haptic devices, surgical robots) as a testbed for incremental prototyping, verification and validation to accelerate the translation of surgical innovations.

The OR-X is broadly positioned at the national level with founding partners from several Swiss universities (UZH, ETH Zurich, University of Bern), other higher education institutions (ZHAW, sitem-insel) and university hospitals (Balgrist, St. Gallen, Geneva, EOC, University Children's Hospital Zurich). It bundles the necessary technical and surgical expertise into a single centre that perfectly complements the existing research landscape. The scientific network will continually expand through OR-X-associated research projects and synergistic infrastructures that share OR-X's strategic objectives.

b. International level
Other large surgical training centres (e.g. IRCAD in Strasbourg for minimally invasive surgery) and research infrastructures include their own operating theatres for conducting intraoperative research (e.g. TU Munich, Johns Hopkins University and King's College London). The OR-X already works in cooperation with many of those institutions, which strengthens its international positioning. National and international collaboration will be implemented through the OR-X network, a scientific network consisting of more than 40 supporters from academia, government and global industry. The OR-X network fosters scientific collaboration and provides researchers and start-ups with access to commercialisation partners, thus increasing the likelihood of R&D investment creating value for Switzerland.

c. Development prospects

The OR-X is expected to emerge as an important hub for surgical excellence through its structural anchoring in the triangle of universities, university hospitals and industry. Through international collaboration and large-scale externally funded projects, the OR-X aims to become an international leader in research on intraoperative imaging, surgeon-enhancing technologies, surgical data science and AI in surgery. The OR-X will thus create long-term added value for a broad spectrum of university research and education, as well as the medtech industry in Switzerland.

Over the longer term, these developments will advance digitalisation in surgery and lead to *in vivo* use of surgical technologies that have a high degree of autonomy and advanced decision-making capabilities. This will make a large impact on quality of care, healthcare systems and society, as it will reduce complications while facilitating, objectifying and optimising treatments in terms of outcomes and costs. The implications for the quality of healthcare education are equally significant, as these technologies will enable more comprehensive and efficient education and training of professionals.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	University of Zurich: 1.00 Schweiz. Verein Balgrist: 13.23	Higher Education Institution	University of Zurich: 3.28 Schweiz. Verein Balgrist: 1.90 ZHAW, University of Bern: 0.30	Higher Education Institution	University of Zurich: 0.50 Schweiz. Verein Balgrist: 1.80
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	SERI[46]: 3.28 ETH Zurich: 0.40	Swiss Confederation	0
Third parties	User fees: 0.42 Sponsoring: 1.00	Third parties	User fees: 3.48 Sponsoring: 0.50	Third parties	User fees: 4.90
Total budget	**15.65**	**Total**	**13.13**	**Total**	**7.20**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	14.00	Investments	2.37	Investments	0
Operating costs	1.65	Operating costs	10.76	Operating costs	7.20
Other costs	0	Other costs	0	Other costs	0
Total costs	**15.65**	**Total**	**13.13**	**Total**	**7.20**

Development Phases	**Years**
Design	2018–2019
Preparation	2020–2022
Implementation	2022–2028
Operation	>2027 (full operations)

46 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

14. Airborne Research for the Earth System (ARES)

Category: Integrated Research Infrastructure
Host institution(s): University of Zurich
Main funding sources: University of Zurich, ETH Zurich, EPFL, Empa, Eawag, University of Lausanne, University of Fribourg, private foundations
Roadmap entry: 2019

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
ARES is composed of three high-precision Earth observing instruments mounted on an airborne platform measuring the electromagnetic spectrum reflected and emitted from the Earth's surface. The complementary instruments comprise i) an imaging spectrometer, ii) a multispectral laser scanner, and iii) 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 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, geometric 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 enhancing the scientific impact of ARES through open data access. The availability of spatially co-registered, temporally coherent ARES products will enable scientists to use big data approaches to explore as-yet unknown interactions between Earth system processes. The ARES team has been relying on heritage imaging spectrometers while the ARES infrastructure is being built: a) the Airborne PRISM Experiment (APEX, www.apex-esa.org) instrument was in operation for a decade until 2019, b) the University of Zurich coordinated research flights with AVIRIS-NG in a research cooperation with the NASA Jet Propulsion Laboratory (JPL) in 2018 and 2021. The ARES imaging spectrometer (Compact Wide Field-of-View Imaging Spectrometer II) was jointly developed by NASA/JPL and the University of Zurich and delivered to the University of Zurich in mid-2022.

With a planned upgrade in 2025–2028, the ARES imaging spectrometer will be complemented by a single-photon waveform laser (airborne laser scanner) and a high-resolution panchromatic camera.

b. International level
ARES remains unique in its setting. Several international key infrastructures use advanced imaging spectrometers as well as LiDAR instruments. Key infrastructures are the Global Airborne Observatory (GAO), 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 (NASA JPL)) and the Airborne Snow Observatory. 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 a larger scale in satellite instruments. The European Space Agency (ESA) as well as the European Union's Earth observation programme Copernicus are developing new satellite concepts (e.g., the Copernicus Hyperspectral Imaging Mission for the Environment, CHIME). NASA's JPL operates the Earth Surface Mineral Dust Source Investigation (EMIT) instrument and the Global Ecosystem Dynamics Investigation LiDAR (GEDI) on the International Space Station and is planning a hyperspectral imager to study surface biology and geology (SBG). 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 quickly changing environment. ARES is in an excellent position to make a unique contribution to the development of these new missions and data cubes, in particular by providing access to environments not yet 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 m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution University of Zurich: 4.70		Higher Education Institution University of Zurich: 5.00		Higher Education Institution	2.50
Canton	0	Canton	0	Canton	0
Swiss Confederation ETH Zurich, Eawag, Empa, EPFL: 4.10		Swiss Confederation SERI[47]: 5.00		Swiss Confederation	0
Third parties ESA/NASA: 2.10 Foundations: 1.10		Third parties SNSF/EU: 0.22		Third parties SNSF/EU: 2.25	
Total budget	**12.00**	**Total**	**10.22**	**Total**	**4.75**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	8.80	Investments	5.49	Investments	0.50
Operating costs	2.00	Operating costs	2.85	Operating costs	2.55
Other costs	1.20	Other costs	1.88	Other costs	1.70
Total costs	**12.00**	**Total**	**10.22**	**Total**	**4.75**

Development Phases	**Years**
Design	2017–2022
Preparation	2017–2021
Implementation	2019–2028
Operation	2023–2032

47 Special support through Art. 47, para. 3 HEdA (Higher Education Act) to be decided in 2024.

Annex I.2: Update of national infrastructures from the 2015 and 2019 Roadmaps

Foreword

An implementation update was carried out between the end of 2022 and the beginning of 2023 for the research infrastructures recommended for implementation in the 2015 and 2019 Roadmaps. This Annex I.2 contains the data collected from the infrastructure management. The infrastructure projects are listed by field:

Humanities and Social Sciences

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

STEM

- Swiss Light Source (SLS 2.0)
- Catalysis Hub (CAT+)
- Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials (Dy-naMatLab)
- 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

Life Sciences

- Swiss Ultrahigh-field-NMR Facility
- 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 of 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 SWITCHlan academic network

Those infrastructures in the 2015 and 2019 Roadmaps which have undergone a major upgrade for the 2023 Roadmap only feature in Annex I.1. These are the High-Performance Computing and Networking (HPCN-28), Airborne Research Facility for the Earth System (ARES), Center of Structural Electron Microscopy (COSEM)[48], Swiss Plasma Center (SPC)[49] and Swiss Data Science Center (SDSC)[50]. The Swiss National Ion-microbe Platform (SwissNIP) and National Research Centre for Animal Cognition did not receive funding and therefore there is not an update for them (see 2019 Roadmap for a description of these two projects).

Some of the infrastructures described here do not meet the new criterion in the 2019 and 2023 Roadmaps, namely the requirement to have a minimum budget of CHF 5 million, as figures here are updates of data in the 2015 Roadmap.

48 This project was initially submitted as a major upgrade (Phases 1 and 2), before it was merged with EM Frontiers in Phase 3 of the 2023 Roadmap process.
49 This project was submitted as a major upgrade under the name of Swiss Fusion Hub for the 2023 Roadmap.
50 This project was submitted as a major upgrade under the name of Swiss Data Science Center+ (SDSC+) for the 2023 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 2025–2028 and 2029–2032 are forecasts and are only given as a rough estimate of probable future costs and how these will be allocated.**
3) **Last information update: December 2022 to January 2023**

1. Linguistic Research Infrastructure (LiRI)

Category: Information and services infrastructure
Host institution(s): University of Zurich
Main funding sources: University of Zurich, Third parties (SNSF)
Roadmap entry: 2019

Description / Development prospects
a. National level
Overview
Two inter-departmental institutions at the Faculty of Arts and Social Sciences at UZH, namely the Centre for Linguistics (LiZZ, Linguistik Zentrum Zürich) and the University Research Priority Programme "Language and Space" (URPP SpuR, 2013 – 2024), as well as some laboratories distributed over the campus and several institutes, successfully implemented a substantial upgrade of existing local linguistic research infrastructure to implement and develop LiRI.

LiRI improves laboratory research in linguistics and related fields, which has become central in the era of Digitisation and Big Data for the study of language and speech. It also supports data acquisition and experimental projects investigating language, speech and the brain with various devices like EEG, fNIRS, Eyetracking, Audio and Video. LiRI also facilitates data storage, data processing and analyses of the data using up-to-date data science support. This upgrade enables pioneering research combining naturalistic data with rigorous methods that so far could only be applied in the lab.

Detailed description
LiRI offers data acquisition services in a new linguistic laboratory unit with devices and components, mainly used for research in phonetics, psycholinguistics, and neurolinguistics, e.g. with mobile and stationary eyetracking devices, EEG systems, an fNIRS system, five sound-proof recording cabins and further facilities. An anechoic chamber will be integrated into the new LiRI laboratory at Forum UZH (from 2028 onwards), building a substantial upgrade and new epicenter of the existing LiRI laboratory.

In addition, LiRI offers researchers assistance in handling and processing their linguistic data at all stages of the data life cycle, from data acquisition to linguistic data management/processing/science/storage. LiRI can channel a large volume of data produced not only by the LiRI data acquisition components, but also data coming from institutions outside of UZH, working with language data and linguistic databases. LiRI ensures that linguistic research data are standardised, interoperable and open accessible resources set up as part of the LiRI rules of procedure as well as a set of standards for the quality of hosted research data, digital assets and metadata.

LiRI is a partner within a consortium that is building a national ecosystem of infrastructures covering the whole linguistic data lifecycle based on ORD requirements (FAIR principles) from data generating, processing and analysing to data sharing and archiving. With the launch of the SWISSUbase repository and the Language Repository of Switzerland (LaRS) in 2022, LiRI is not only a strong partner in these initiatives, but also serves as a national platform for linguistic data storage/processing/science, uniting many different linguistic data resources (text, audio, video, EEG etc.) in one data center. Working with CLARIN-CH, LiRI helps to set up national working groups, e.g. on corpus linguistics, speech & brain studies, and thus strengthens national cooperation.

b. International level
As an infrastructure unit within the Centre for Linguistics, the LiRI plays a key role in Zurich linguistics research, which is Switzerland's largest linguistic research community (over 20 full professors, manyfold third-party funded projects and a huge number of local research and training initiatives). International collaborations and the international Advisory Board have helped to make LiRI one of the very few large laboratory and data management units for linguistics (and related disciplines) in Europe.

LiRI is also embedded in European infrastructure initiatives. UZH works with CLARIN-CH, which is also hosted by the Center for Linguistics, and DARIAH, two pan-European organisations that support the sharing of language resources and tools for arts and humanities scholars working with computational methods. The membership in these two organisations enables the research community to contribute to and to benefit from the two most important European infrastructure networks. Through systematic metadata and format requirements they help

to implement and improve the reusability and reproducibility of data in linguistic subdisciplines to reach a higher level of knowledge gain.

c. Development prospects

LiRI brings UZH and its national and international partners to the forefront of experimental and Big Data-based linguistic research, also taking into consideration the European funding agencies' policy of sustainable research infrastructures. The new devices, synthetic lab structure and staff (data scientists and consultants for statistics, machine learning, data aggregation, one technician, system administrator, linguistic application engineers, research coordinator) enable the number and size of third-party funded projects with university and business partners to grow both nationally and internationally (e.g. hearing aids, brain-computer interfaces, neuromodulation, learning and training software). The NCCR Evolving Language (start: June 2020) is an important collaboration partner of LiRI, also several Sinergia projects (e.g. MULTICAST, ProPOS). Thanks to close collaboration with CLARIN-CH and the SWISSUbase repository facility, LiRI is a strong partner for research initiatives within and beyond Switzerland with regard to support in data storage (also long-term archiving), data management and data science.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	UZH: 4.90	Higher Education Institution	UZH: 4.40	Higher Education Institution	UZH: 3.30
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	0
Third parties	SNSF: 0.80 (R'Equip) User fees: 1.20	Third parties	User fees: 1.50	Third parties	User fees: 1.80
Total budget	**6.90**	**Total**	**5.90**	**Total**	**5.10**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	2.40	Investments	1.20	Investments	0.40
Operating costs	4.40	Operating costs	4.60	Operating costs	4.60
Other costs	0.10	Other costs	0.10	Other costs	0.10
Total costs	**6.90**	**Total**	**5.90**	**Total**	**5.10**

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

2. Swiss Art Research Infrastructure (SARI)

Category: Information and services infrastructure
Host institution(s): University of Zurich
Main funding sources: University of Zurich, ETH Zurich, external Foundations
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Swiss Art Research Infrastructure (SARI) provides access to advanced data-driven research tools and domain-specific research environments, allowing unified and mutual access to research and collection data, digitised visual/textual resources, and related reference data in the field of art history and related disciplines. By providing universal access to pivotal digital research technologies and re-sources through its modular, tailor-made research environments, SARI enhances the accessibility, interoperability, re-usability, and long-term sustainability of research and collection data in art history and related disciplines according to FAIR principles. Thus, SARI combines the unique scholarly expertise of specialised research institutions in Switzerland and leverages the vast scholarly potential of open research data as well as collection data, anticipating the research needs of the next decades.

Detailed description
SARI develops and maintains a comprehensible technological framework for unified access to domain-specific research resources, advanced research tools, and tailor-made research environments based on internationally acknowledged, sustainable, and yet extendable standards for data modelling, data storage and data exchange in the semantic web. This includes (but is not limited to) the Resources Description Framework (RDF) and Linked Open Data technology (LOD) for semantic data technology, the International Image Interoperability Framework (IIIF) for access to digital assets, as well as the Conceptual Reference Model of the International Council of Museums (CIDOC-CRM) and the Linked.Art framework for collecting, modelling, harmonising, aligning, enhancing, and publishing data.

Built entirely on open source components and according to standards recommended by the W3C, SARIs technology stack (by design) guarantees long-term findability, accessibility, interoperability, and re-usability of research and collection data in compliance with the Swiss National Open Research Data Strategy and FAIR principles. Moreover, due to their semantic nature, all data made available through SARI are part of a global knowledge graph, compatible with the relevant national and international research infrastructures. This results in an unprecedented framework for publishing research data, first-hand digital visual resources, and scholarly acknowledged reference data from specialised research institutions across the globe, overcoming institutional and national barriers as well as technical and language issues. By working with leading national and international institutions in the field, SARI fosters cost-effective use of resources for research and teaching across disciplines.

b. International level
To ensure maximum leverage nationally and internationally, SARI uses the same technology stack as major cultural institutions worldwide (Getty Research Institute, GRI, Yale Center for British Art, YCBA, British Museum, PHAROS Consortium) allowing mutual access to research resources. Pivotal extensions to semantic ontologies are being developed in cooperation with the CIDOC-CRM special interest group and the Linked.Art consortium. Multilingual, domain-specific reference vocabularies are being developed in cooperation with major national and international players (libraries, research institutions, etc.). As a result, SARI's semantic modelling and tools are currently being adopted by leading institutions in the field, such as the Harvard Centre for Renaissance Studies, Villa I Tatti (Florence), the Bibliotheca Hertziana (Rome), and the Institute for the History of Science (Berlin). SARI deepened international networking as a permanent member of the CIDOC-CRM Special Interest Group (CRM-SIG), the editorial board of the Linked.Art consortium, and as founding member of both CORDH (Consortium for Open Research Data in the Humanities) and the Time Machine Organization (TMO).

c. Development prospects
In view of the ever-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 fast-growing demand

for advanced digital research technology, research tools and universal access to digital research resources from specialised institutions. 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 actively involved in numerous research project proposals to CHORD, SNSF, ERC and others to pursue its mission to provide advanced digital research tools and environments. To avoid redundancies on a national level, SARI is closely working with leading national partners, such as DaSCH and CONNECTOME. In this, SARI is establishing practices for data modelling, exchange, and re-use that are specific to the field of art history, but reusable in the DH at large. At the University of Zurich, SARI has acquired the status of Technology Platform (TPF), which allows it to provide services to a larger range of clients (academic and non-academic).

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution University of Zurich: 0.87 University of Zurich (invest): 0.24		Canton University of Zurich (invest): 0.24		Higher Education Institution University of Zurich (invest): 0.24	
Canton	0	0		Canton	0
Swiss Confederation ETH Zurich (in-kind/projection): 0.44		Swiss Confederation ETH Zurich (in-kind/projection): 0.44		Swiss Confederation ETH Zurich (in-kind/projection): 0.44	
Third parties Private Foundations: 1.23 TPF revenue (academic/SNSF): 0.38 TPF revenue (non-academic): 0.38 Zurich Research Center/MPG: 1.25		Third parties Private Foundations: 0.08 TPF revenue (academic/SNSF): 0.59 TPF revenue (non-academic): 0.59		Third parties TPF revenue (academic/SNSF): 0.59 TPF revenue (non-academic): 0.59	
Total budget	**4.79**	**Total**	**1.94**	**Total**	**1.86**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0.24	Investments	0.24	Investments	0.24
Operating costs	1.99	Operating costs	1.26	Operating costs	1.18
Other costs	2.56	Other costs	0.44	Other costs	0.44
Total costs	**4.79**	**Total**	**1.94**	**Total**	**1.86**

Development Phases	**Years**
Design	(2014–)2017
Preparation	2017
Implementation	2018–2022
Operation	2020ff

3. Swiss National Data and Service Center for the Humanities (DaSCH)

Category: Information and service infrastructure
Host institution(s): University of Basel
Main funding sources: Swiss National Science Foundation, University of Basel
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Swiss National Data and Service Center for the Humanities (DaSCH) provides data curation, long-term access, persistent identifiers for data records (based on the "Archival Resource Key", ARK) and research and analysis tools for research data in the humanities. The focus is on qualitative data, which mostly consists of complex interwoven data, such as textual data and associated digital objects like images, sound or video files. DaSCH guarantees the long-term direct accessibility of research data in the Humanities and the adherence to open standards while propagating the use of advanced digital methods and technologies so that the persistence of data can be secured and tools to work with those data can be supplied. DaSCH provides FAIR access to its data and supports relevant standards for interoperability.

Detailed description
DaSCH develops and maintains a software solution, the DaSCH Service Platform (DSP), which consists of a database (triplestore) based on Linked Open Data technologies (LOD) and the Resource Description Framework (RDF). The latter is a middleware utility that implements 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 modeling with LOD allows DaSCH to use a single infrastructure for data, metadata, models and structures from any project, regardless of the data concept used. The architecture of DSP goes well beyond the Open Archival Information System (OAIS) reference model for digital archives, where OAIS only emulates the processes of an analogue archive, containing physical artifacts, into the digital domain. For qualitative research data, this model is not sufficient: The data themselves, not just their descriptive metadata, need to be searchable at any time. In addition, data have to be annotable and linkable on a very fine-grained level. In addition, the data objects need to be editable, e.g. if new findings emerge, without losing previous versions. The field level-based version history of DSP offers these features and therefore the term keep-alive archive is used. Citations using permanent identifiers, based on archival resource keys (ARK, provided by DaSCH), always show a data object as it was at the time when the ARK identifier was created. An important aspect of qualitative data in the humanities is that the preservation of such datasets alone may make little sense. The way the datasets are accessed and re-used by queries and views often form an integral part of the knowledge represented by the datasets. Thus, the DaSCH infrastructure provides components to emulate queries and generic user interfaces using modern responsive web technologies.

DaSCH implements, encourages or enforces the use of well adapted and accepted standards. Its RESTful API is based on JavaScript Object Notation – Linked Data (JSON-LD) which is a widely accepted standard for linked open data. For images, audios and videos, DaSCH only uses the International Image Interoperability Framework (IIIF), texts can be imported/exported as standard TEI/XML (Text Encoding Initiative). Therefore, DaSCH consistently guarantees a high degree of interoperability. DaSCH is also fully compliant with FAIR data principles as required by most funding agencies. If needed, more precise access control is also possible (e.g., copyright issues or data protection rules).

b. International level
International comparison shows that there is no single repository that can meet everyone's needs. There are various approaches aimed at ensuring long-term access to research data. The DaSCH solution compares favourably with similar systems used worldwide. DaSCH uses an adequate, very advanced and innovative technology that is very promising for the future and offers great potential. It is open to international co-operation by using accepted standards such as IIIF, LOD, RDF, REST or JSON-LD and works closely with similar national and international institutions.

c. Development prospects

Research in the Humanities has become more reliant on digital data, tools and methods. Combined with the fact that several Swiss universities have created "Digital Humanities" departments and research data stewards or comparable structures, demand for DaSCH services and long-term storage of curated data in the Humanities will increase. DaSCH is intended as a sustainable solution for digital editions. It also contributes to the definition and establishment of a standard for 3D images (IIIF 3D), and is designed to provide a generic virtual research environment where added value can be created by searching and analysing data across multiple projects with the help of suitable data analysis tools. In order to avoid redundancy, DaSCH works with other national and international infrastructures and institutions such as FORS. Common standards for software platforms (e.g. LOD, RDF, ontologies) enable efficient knowledge sharing with them. Common portals and data gateways are planned in order to offer single-stop services for research projects that cross domain boundaries.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution University of Basel: 1.10		Higher Education Institution University of Basel: 1.10		Higher Education Institution	tbd
Canton	0	Canton	0	Canton	tbd
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	tbd
Third parties SNSF: 9.20 SAGW: 0.23		Third parties SNSF: 10.25 0.20		Third parties	tbd
Total budget	**10.53**	**Total**	**11.55**	**Total**	**tbd**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	1.26	Investments	1.96	Investments	tbd
Operating costs	8.95	Operating costs	9.24	Operating costs	tbd
Other costs	0.32	Other costs	0.35	Other costs	tbd
Total costs	**10.53**	**Total**	**11.55**	**Total**	**tbd**

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

4. Mixed-Reality Lab for Behavioral Research (MIRAL)

Category: Instruments, Information and service infrastructures, Technical infrastructures
Host institution(s): University of St.Gallen
Main funding sources: University of St.Gallen
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
With the Mixed Reality Lab for Behavioural 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 the behaviour of students, consumers, managers, and employees in both physical and computer-enhanced environments.

Detailed description
With its combination of neurophysiological measurement capabilities, AR/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, but it is also considerably increasing its scope of action. To scientists in Switzerland and elsewhere, MIRAL is a unique research environment that further improves the reputation of the university and Swiss research in general. MIRAL also enhances the reputation of the research community by providing a specialised lab infrastructure to research human behaviour in both the physical and virtual world by applying sophisticated neurophysiological measurement techniques.

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. MIRAL also directly works with other laboratories in Europe.

c. Development prospects
MIRAL was 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. In the second stage (2018–2021), MIRAL extended its neurophysiological measurement capabilities (EEG, ECG, GSR), augmented/virtual reality resources, and developed its lab team's capabilities for enhanced support to improve the quality of scientific experiments. MIRAL now includes a common laboratory infrastructure to address research questions in the real, physical, and virtual, online world. Furthermore, MIRAL has taken a special focus on neurophysiological measurements by directly supporting studies and actively contributing to academic discussion in the field. During the next stage (2021-2024), MIRAL will deepen its excellence in neurophysiological measurements (both in the lab and in the field), seek ways to integrate augmented reality with aforementioned measurement technics, and further support studies and researcher training in behavioural science.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0.92	Higher Education Institution	1.05	Higher Education Institution	1.20
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	0
Third parties	0	Third parties	0	Third parties	0
Total budget	**0.92**	**Total**	**1.05**	**Total**	**1.2**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0.08	Investments	0.10	Investments	0.12
Operating costs	0.84	Operating costs	0.95	Operating costs	1.08
Other costs	0.0	Other costs	0.0	Other costs	0
Total costs	**0.92**	**Total**	**1.05**	**Total**	**1.20**

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

5. Swiss Light Source SLS 2.0

Category: Instrument
Host institution(s): PSI
Main funding sources: ETH Board, PSI, Canton Aargovia
Roadmap entry: 2019

Description / Development prospects
a. National level
Overview
Since it became operational in 2001, the Swiss Light Source (SLS) has remained one of the prime examples of third-generation storage-ring technology for over a decade. However, SLS must now undergo a comprehensive upgrade to remain competitive and able to be used for cutting-edge research. This is due to a number of factors: the increasing scope and impact of applications for synchrotron light sources in almost all areas of the natural and engineering sciences; improvements in source and instrument technology in general; and the advent of diffraction-limited storage-rings (DLSRs) in particular.

SLS 2.0 will provide a dramatic increase in brightness (up to a factor of 40) by replacing the current magnet lattice of the storage ring with a new multi-bend achromat (MBA) magnet structure. This upgrade will also increase electron beam energy from 2.4 GeV to 2.7 GeV. This, combined with advanced hardware and instrumentation, will enhance the performance of all experimental techniques currently used at the SLS and also enable the development of new innovative methods. SLS 2.0 will perfectly complement the 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.

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

Detailed description
The upgrade focuses on the transformation of the storage ring lattice to MBA technology and the up-grade of the beamlines and end stations to take full advantage of the increased brightness of the ma-chine. 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 imaging 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, which benefits clinical medicine, fundamental and applied sciences. SLS 2.0 will generate more brilliant and harder x-ray beams with greater 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-micrometer scale crystals of proteins, 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 contemporary and future technological importance.

b. International level
The first DLSR at MAX-IV in Lund, Sweden, came online in summer 2016. Sirius in Campinas/Brazil, started commissioning in 2021, while the ESRF implemented its upgrade to DLSR-status in 2019 and restarted user operation in 2020. The ALS in Berkeley/USA and the APS in Argonne/USA will perform their upgrades on a similar timescale as SLS. Other facilities in Europe, like Elettra in Trieste/Italy, Petra in Hamburg/Germany and Diamond in Didcot/UK are in an advanced state of planning, but will not start with implementation of their synchrotron upgrades before 2025. The same is true for Spring8/Japan. The SLS2.0 project team has established several collaborations with these facilities, thus profiting from synergies for a large variety of developments in hardware and methods required for the new generation of synchrotrons and related instrumentation.

c. Development prospects
The SLS 2.0 upgrade requires substantial novel technical developments, including complex magnetic deflection

systems completely built using permanent magnet technology. This will not only enable integration of magnet functions in a smaller footprint. It will also lead to significantly reduced power consumption. The upgrade of the SLS will on the one hand significantly enhance the quality - and in many cases also the speed - of existing experimental methods. It will also lead to entirely innovative techniques in areas as diverse as advanced manufacturing, drug design, and electronic-device manufacturing and characterisation. It is thus of utmost importance that the SLS upgrade programme keeps PSI at the forefront of cutting-edge science over the next two decades. In addition, and as a key element of PSI's core mission, continuous upgrades of both the machine and end stations will be performed during the operating phase in order to ensure long-term competitiveness.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	tbd
Canton	Kt. AG: 3.25	Canton	Kt. AG: 6.50	Canton	tbd
Swiss Confederation	ETH Board: 99.00 PSI: 68.00	Swiss Confederation	PSI: 29.00	Swiss Confederation	tbd
Third parties	0	Third parties	0	Third parties	tbd
Total budget	**170.25**	**Total**	**35.50**	**Total**	**tbd**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	119.25	Investments	15.50	Investments	tbd
Operating costs	0	Operating costs	0	Operating costs	tbd
Other costs	51.00	Other costs	20.00	Other costs	tbd
Total costs	**170.25**	**Total**	**35.50**	**Total**	**tbd**

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

6. Catalysis Hub (CAT+)

Category: Technical infrastructure
Host institution(s): ETH Zurich and EPF Lausanne
Main funding sources: ETH Board, ETH Zurich, EPF Lausanne, SNSF, EU
Roadmap entry: 2019

Description / Development prospects
a. National level
Overview
The Catalysis Hub (Cat+) provides a unique integrated research infrastructure for the efficient discovery of catalytic technologies for sustainable conversion processes and energy research. This 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
Cat+ is designed as an open-access facility for catalysis research. It will be devoted to the discovery, characterisation and 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 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 efficient dissemination within Switzerland: the East Campus (ETH Zurich/Empa) and West Campus (EPFL) of the 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 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 a transition to a sustainable model ensuring long-term prospects and later upgrades of Cat+.

Costs (in CHF m)

2021–2024		2025–2028		2029–2032	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	0
Canton	0	Canton	0	Canton	0
Swiss Confederation ETH Board: 25.00 ETH Zurich, EPFL: 6.90		Swiss Confederation ETH Board: 8.10 ETH Zurich, EMPA, EPFL: 3.00		Swiss Confederation ETH Board: 5.70 ETH Zurich, EPFL: 1.40	
Third parties SNSF, EU: 0.50 Private sector: 0.30		Third parties SNSF, EU: 1.40 Private sector: 0.80		Third parties SNSF, EU: 2.10 Private sector: 2.20	
Total budget	**32.70**	**Total**	**13.30**	**Total**	**11.20**

Costs overview (2021–2024)		2025–2028		2029–2032	
Investments	20.20	Investments	4.30	Investments	2.00
Operating costs	6.70	Operating costs	7.10	Operating costs	7.20
Other costs	5.8	Other costs	1.90	Other costs	2.0
Total costs	**32.7**	**Total**	**13.30**	**Total**	**11.20**

Development Phases	Years
Design	2019–2021
Preparation	2021–2022
Implementation	2023
Operation	2024ff

7. Swiss Laboratory for the Advanced Studies on the Dynamic Behaviour of Materials (DynaMatLab)

Category: Instruments
Host institution(s): SUPSI
Main funding sources: Host institution, Competitive Funds, State Secretariat of Education, Research and Innovation (SERI)
Roadmap entry: 2015

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 accurately measure the stress-strain curves of materials in tension, compression and shear in 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 a key player supporting the design, development and optimisation of production processes.

The laboratory develops research on materials and structures subject to dynamic-impulsive loads, facilitates technological transfer and promotes an integrated approach to design-testing as a means of improving the safety and quality of products.

Detailed description
In the laboratory it is possible to perform tests in tension, compression, shear, torsion and bending for different materials at high strain-rates and in a large range of temperatures (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.
- Aluminum and magnesium alloys used in aerospace.
- Fibre-reinforced composite polymers.

The core facilities of the laboratory are based on the Modified Hopkinson Bars apparatus. Several set-ups are used to study the uni-, bi- and tri-axial behaviour of materials in a wide range of strain-rate tests ($1÷10^{5}$ s^{-1}). These apparatuses may differ in length from a few meters up to 15 m, and have different bar diameters, needed to test for example: metals (diameter 10 and 12 mm); polymers (diameter 20 mm); concrete and rocks (diameter 60 mm). Additional facilities exist 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.) enable all data to be captured.

b. International level
The Swiss Laboratory for Advanced Studies on the Dynamic Behaviour of Materials continues in the same way followed by the existing DynaMat Laboratory. The research infrastructure will enhance our role as a reference point for industries, research centres and 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 of the network of world's 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.

Our laboratory is highly 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 these areas, new machines need to be designed to constantly improve the present set of devices and create complementary set-ups. New machines are crucial in addressing R&D needs in the field of dynamic behaviour of materials. In order to cover a wide area of applications, torsion behaviour and combined tension/torsion need to be studied. Traditional

Split Hopkinson Pressure Bar (SHPB) can easily respond to 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 bi-axial apparatus at medium and high strain rate (bi-axial 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 m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	2.72	Higher Education Institution	2.17	Higher Education Institution	2.17
Canton	1.18	Canton	0.93	Canton	0.93
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	0
Third parties	1.00	Third parties	1.20	Third parties	1.20
Total budget	**4.90**	**Total**	**4.30**	**Total**	**4.30**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0.59	Investments	0.40	Investments	0.40
Operating costs	3.46	Operating costs	3.46	Operating costs	3.46
Other costs	0.84	Other costs	0.44	Other costs	0.44
Total costs	**4.90**	**Total**	**4.30**	**Total**	**4.30**

Development Phases	**Years**
Design	2017–2024
Preparation	2024–2026
Implementation	2026–2028
Operation	2028–2032

8. Next Evolution in Sustainable Building Technologies (NEST)

Category: Technical Infrastructure
Host institution(s): Empa, Eawag
Main funding sources: Empa, Eawag, ETH Board, Swiss Federal Office of Energy, Ernst Göhner Stiftung, Swisslife/ ZKB and numerous industrial partners
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
Since its inauguration in May 2016 NEST has become a lighthouse for innovation in the building sector. A vast number of research groups from the ETH Domain and universities of applied sciences together with their industrial partners (presently more than 150) are using NEST to explore the viability of new materials, systems and concepts.

The unique flexibility of NEST combined with the involvement of real users in all experiments has proven to be a true catalyst for innovation. First, products and concepts that were initially developed within the NEST framework are already on the market and many more are in the pipeline. Several startups have emerged in recent years that seek to commercialise technologies first deployed in NEST. Furthermore, NEST still enjoys very broad coverage in the national and international press, repeatedly wins awards and since its launch 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 financing for the construction of the backbone was secured. 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, six more units have been completed: Solar Fitness & Wellness (Empa), Urban Mining and Recycling (KIT), SolAce (EPFL), DFAB HOUSE (ETH Zurich), HiLo (ETH Zurich) and Sprint (Empa). The unit STEP 2 will be completed in 2023.

NEST has been involved in co-founding and supporting business and research ecosystems to facilitate the transformation of the construction industry – for example, in the field of circular construction and in energy issues.

Numerous peer reviewed papers and master thesis have been published in combination with the units. NEST is definitely helping to accelerate innovation in the construction industry. The gap between academia and industry can be narrowed thanks to 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 is no comparable platform offering a similar approach that is research- rather than user-dominated. The number of international delegations from the public sector and from research and industry is increasing. Several large international companies have recently joined NEST as partners or are planning to do so in the near future. Collaborations have been established with highly regarded institutions such as Imperial College, University of Stuttgart, KIT, TU Wien and others.

c. Development prospects
Three units are currently under development. ZERO is tackling the challenge of CO_2-neutral or CO_2-negative building materials. The second project, DRONE HUB will be an accelerator for drone related construction and operational processes. With drone hub, a different type of industry partner can be approached. STEP2 unit drives innovation in the NEST focus areas circular economy, industrial and digital fabrication, building envelope and energy systems; and will be built in 2023.

Again, user acceptance of such new concepts will be one of the central parts of research. While in the early

years, the focus was very much on the development of new units, in the coming years, greater emphasis will be placed on research carried out during operation of the units. This research should help to increase the market readiness of solutions developed within NEST. Another goal is to further supporting ecosystems that transform industry. And especially to support federal efforts to acquire and build more sustainable solutions.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	0
Canton	0	Canton	0	Canton	0
Swiss Confederation Empa, Eawag, ETH–Board	15.47	Swiss Confederation Empa, Eawag, ETH–Board	18.24	Swiss Confederation Empa, Eawag, ETH–Board	18.24
Third parties	2.77	Third parties	4.00	Third parties	4.00
Total budget	**18.24**	**Total**	**22.24**	**Total**	**22.24**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	4.95	Investments	7.84	Investments	7.54
Operating costs		Operating costs		Operating costs	
Direct	5.29	Direct	6.40	Direct	6.70
Other costs		Other costs		Other costs	
Technical operation, support	8.00	Technical operation, support	8.00	Technical operation, support	8.00
Total costs	**18.24**	**Total**	**22.24**	**Total**	**22.24**

Development Phases	**Years**
Design	2021–2032
Preparation	2021–2032
Implementation	2021–2032
Operation	2021–2032

The development phases and the corresponding years above apply to the recent developments of the infrastructure. For previous development phases please refer to Roadmaps 2015 and 2019.

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

Category: Instrument
Host institution(s): University of Zurich
Main funding sources: SNSF, FLARE, ERC
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
DARk matter WImp search with Noble liquids (DARWIN) is a new observatory in astroparticle physics, with the aim of identifying the nature of dark matter, revealing the nature of neutrinos (via the search for neutrinoless double beta decay of ^{136}Xe), observing solar neutrinos via elastic neutrino-electron and coherent neutrino-nucleus scatters, as well as solar axions and axion-like particles. DARWIN will employ a time projection chamber (TPC) filled with liquid xenon (50 tons in total, 40 tons 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 12 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 XENONnT experiment. 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 led by Swiss groups, is the successor of the very successful XENON program, with leading contributions from the UZH group. The XENON1T experiment, based on a xenon TPC with 3.2 tons of liquid xenon in total, has created the world's best constraints on the interactions of dark matter particles with nucleons for particle masses above 6 GeV. XENONnT, using 8.6 tons of liquid xenon, is currently generating scientific data, and released first world-leading results in 2022. UZH is extensively 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 the R&D and design phase, supported by three ERC grants. As part of the ERC project, the UZH group is focusing on optimisation of the TPC, namely its light and charge readout. The UZH group constructed a vertical TPC prototype, Xenoscope, to demonstrate electron drift over 2.6 m (the final size of the DARWIN TPC), and is investigating new, solid-state photosensors (SiPMs) as well as novel photomultiplier tubes (PMTs), which are excellent candidates to replace the existing, 3-inch diameter PMTs.

b. International level
The DARWIN observatory will be built and operated by an international consortium of 38 groups from Europe, Asia, USA and Australia. In addition, in July 2021 the members of the DARWIN/XENON collaborations signed an MoU with the members of the LZ collaboration to form the XLZD consortium (xlzd.org) to design, construct, and operate a new, single, multi-tonne scale xenon observatory and to exploit its science potential. The consortium will evolve into a full collaboration once the project leaves the R&D phase. Nearly 600 authors from the new consortium, as well as other interested colleagues, have contributed to and signed an extensive White Paper covering all the physics channels that can be studied with a large-scale, low-background LXe-based astroparticle physics detector like DARWIN.

DARWIN is on the roadmap of the Astroparticle Physics European Consortium (APPEC), which has published its strategy for the years 2017–2026. It is also on several national roadmaps (e.g. Germany and Netherlands). With an expected exposure of 200 tonnes x years, DARWIN will probe cross sections of dark matter particles down to 2 x 10^{-49} cm^2, more than an order of magnitude below the sensitivity of the current XENONnT, and will thus reach the so-called neutrino fog, where nuclear recoil signals from atmospheric and supernovae neutrinos will create 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. For the first time, the observatory will also be able to measure 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. This discovery will have far-reaching implications, proving that neutrinos are their own antiparticles.

c. Development prospects

The goal of the present MoU on DARWIN is to coordinate the R&D work that will serve as the basis for the Conceptual Design Report to be submitted in late 2023. This will be followed by engineering studies and a Technical Design Report, expected for 2024/25. The construction phase will last from 2025-2027, with commissioning and start of scientific data collection planned for 2028 and 2029, respectively. The observatory is intended to capture data for at least ten years. We note that total project costs will depend on the xenon gas price, which is currently very high due to the geopolitical situation. However, xenon gas will be an asset and thus an investment, and can be sold at the end of the project.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
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): 1.50 EU (ERC UZH): 1.5 (Euro, 1.46) EU (ERC Freiburg/Münster): 1.5 (Euro, 1.46) International partners: 25.00		Third parties SNSF (FLARE): 3.00 EU (ERC Münster): 2.5 (Euro, 0.97) International partners: 52.00		Third parties SNSF (FLARE): 1.50 International partners: 27.00	
Total budget	**29.50**	**Total**	**57.50**	**Total**	**28.50**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	28.00	Investments	56.00	Investments	27.00
Operating costs	1.50	Operating costs	1.50	Operating costs	1.50
Other costs	0	Other costs	0	Other costs	0
Total costs	**29.50**	**Total**	**57.50**	**Total**	**28.50**

Development Phases	**Years**
Design	2015–2024
Preparation	2025–2027
Implementation	2028–2029
Operation	2029–2039

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

Category: Instument
Host institution(s): PSI
Main funding sources: ETH Domain, PSI, Canton Aargovia
Roadmap entry: 2015

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 nanometer. 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 chemi-cal bond. SwissFEL is designed to cover a wide range of x-ray energies. Phase I of the SwissFEL pro-ject was successfully completed once users were given access to the hard x-ray beamline ARAMIS in 2019. Phase II of the project, the ATHOS beamline, expands the capabilities to soft x-rays (250 to 1900 eV) and doubles the scientific capacity of SwissFEL. First laser light from ATHOS was obtained at the end of 2019 and the first pilot user experiments were conducted in 2021.

ATHOS provides 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 a third experimental station to be added after 2022. As a next-generation cutting-edge research infrastructure, ATHOS (together with the other research infrastructures at PSI), will play an important role in the scientific portfolio of Switzerland. SwissFEL with its two beamlines ATHOS and ARAMIS complements the access that Swiss users have to European XFEL, an international research organisation based in Hamburg, of which Switzerland is a member.

Detailed description
Since first lasing in December 2019 with only two undulator modules, ATHOS instrumentation has been greatly expanded:

- Maloja, the first experimental station for atomic, molecular and non-linear X-ray physics and chemical dynamics, received the first XFEL beam in June 2020 and began user operation in spring 2022.
- Furka, the second experimental station for ultrafast spectroscopy in quantum materials, received first light in August 2021 and will start user operation in spring 2023.
- The PolariX deflecting cavity, an important diagnostic system to monitor the energy distribution of electrons in function of time downstream the undulator line, was successfully commissioned in August 2022. This device is important for the set-up and improvement of special ATHOS operation modes.

All of the established ATHOS specifications were met or even exceeded. The FEL pulse energy was gradually increased to reach the millijoule level, which is a thousand times higher than the level achieved with the first lasing. Equally important to the peak power is the repetition rate of FEL pulses which could reach the nominal 100 Hz in parallel to ARAMIS operatio – this essentially doubles SwissFEL capacity to run experiments. The versatility of the ATHOS FEL could be demonstrated by operating the line in different modes: Two FEL pulses (350 eV and 915 eV) with variable time separation (30 to 500 fs) can be generated thanks to the chicane concept. Tunable pulse duration from 50 to a few femtoseconds obtained by tilting the beam is in regular use. The light polarisation can easily be changed thanks to the ATHOS APPLE X undulators. Reduction of the saturation length by 20% thanks to the optical klystron mode of operation (worldwide unique at ATHOS) is used for daily operation.

b. International level
The particularity of the ATHOS FEL lies in its operation flexibility to control the most important laser parameters over large ranges. ATHOS is the only FEL worldwide using chicanes between every undu-lator, which offers a variety of operation modes leading to considerable parameter tunability in the soft x-ray photon energy range.

The novel design of the ATHOS APPLE X undulators has attracted great international interest and the ATHOS team has established several collaborations with other facilities. Together with Daetwyler, the Swiss producer of the APPLE X, PSI delivered four undulator units to the European X-FEL facility in 2021.

c. Development prospects

SwissFEL with its two beamlines is available to national and international users and offers novel experimental opportunities for fundamental and applied research topics. Many of the research findings produced at the ATHOS beamline will lead to important discoveries relevant to a large variety of fields, encompassing topics as energy conversion, more efficient drug development and the design of smaller computer chips.

In order to further increase the capability of ATHOS, an X-ray beam seeding project partially financed by ERC (HERO Project) was launched and will be completed in 2023. This seeding scheme uses an external conventional laser to modulate the electron density of each batch. Once HERO has been completed, ATHOS will be the first FEL producing attosecond pulses almost fully coherent in time and transverse space in the soft x-ray photon energy range.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	0	Higher Education Institution	0	Higher Education Institution	tbd
Canton	0	Canton	0	Canton	tbd
Swiss Confederation	PSI: 15.00	Swiss Confederation	PSI: 11.00	Swiss Confederation	tbd
Third parties	SNSF: 1.00	Third parties	SNSF: 1.00	Third parties	tbd
Total budget	**16.00**	**Total**	**12.00**	**Total**	**tbd**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	8.00	Investments	4.00	Investments	tbd
Operating costs	8.00	Operating costs	8.00	Operating costs	tbd
Other costs	0	Other costs	0	Other costs	tbd
Total costs	**16.00**	**Total**	**12.00**	**Total**	**tbd**

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

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

Category: Technical infrastructures: (e-infrastructure, STEM)
Host institution(s): University of Geneva, EPFL, FHNW
Main funding sources: SERI
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Common Data Centre Infrastructure (CDCI) was created in 2017 to foster the development of data centre activities for space- and ground-based astrophysical facilities, including astroparticle physics and cosmology. The CDCI is based on 20 years of experience of the INTEGRAL Science Data Centre in Geneva, which is in charge of the scientific ground-segment operations of ESA's INTEGRAL space observatory. A major goal of the CDCI is to ensure the long-term preservation of the data and data analysis expertise after the mission is terminated, in particular through the deployment of web services. After an unsuccessful attempt to expand the scope of CDCI, we are now focusing on our core activities.

Detailed description
The CDCI is the result of extensive activities at the University of Geneva with the establishment in 1995 of a data centre for ESA's gamma-ray observatory INTEGRAL, the INTEGRAL Science Data Centre (ISDC). This centre processes and archives INTEGRAL data and provides analysis software to the community. Based on the success of the ISDC, we developed widely recognised expertise, which allowed us to contribute to a number of different space astrophysics projects, such as ESA's Planck, Gaia, CHEOPS and Euclid missions, and the Sino-Swiss mission POLAR. Participation in these projects has been largely funded through specific SERI Swiss Space Office programmes. However, the increase in the number of missions calls for a dedicated infrastructure to support the different projects in the areas of contract management, computer system administration, software and web services, and software development.

The main goal of the CDCI is to offer a shared infrastructure to any project involved with data centre developments for astrophysics, astroparticle physics and cosmology. EPFL and FHNW are now participating in the CDCI. The CDCI will offer its services to all Swiss scientists interested in participating in data centre activities in the domain of astrophysics at large. In the early-development phases, the CDCI will offer support to scientists working on preparations for the Swiss contribution to the proposed missions, including negotiations with the different partners and drawing up 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. Depending on available resources, the CDCI may also directly contribute to software and algorithm development, if requested by the P.I.

Another of the CDCI's tasks is the preservation of data from current and past missions and its dissemination to the widest possible community. 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 not only maintains the data archives and software, but also provides web services for running simplified and yet powerful and fully validated analyses. To this end, the CDCI employs modern software technologies using container deployment in the 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
Astrophysics missions are often the result of large international collaborations; the activities of the CDCI are therefore very relevant at the international level. The current focus is on space missions from ESA, but there is a strong interest in missions led by the USA, Japan, and China. Ground-based facilities 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 give Switzerland high visibility in these projects.

c. Development prospects

Data centre activities for astrophysics in Switzerland started with INTEGRAL. Significant developments have been made with the participations in Planck, Gaia, CHEOPS and EUCLID. Several future projects are currently in preparation. The inclusion of ground-based facilities will heighten the need for the CDCI. However, the ambitions of the CDCI are strongly limited by the availability of funding, which is very unclear at the moment.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	1.71	Higher Education Institution	1.70	Higher Education Institution	1.70
Canton	0	Canton	0	Canton	0
Swiss Confederation	SERI/SSO 1.21	Swiss Confederation	0	Swiss Confederation	0
Third parties	swissuniversities 0.62 ESA: 0.60	Third parties	SNSF 0.3 ESA: 2.00	Third parties	SNSF 0.30 ESA: 2.00
Total budget	**4.14**	**Total**	**4.00**	**Total**	**4.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0.20	Investments	0.40	Investments	0.40
Operating costs	3.94	Operating costs	3.60	Operating costs	3.60
Other costs	0	Other costs	0	Other costs	0
Total costs	**4.14**	**Total**	**4.00**	**Total**	**4.00**

Development Phases	**Years**
Design	2014–2015
Preparation	2015–2016
Implementation	2016–2017
Operation	2017–2032

12. Center for Biomedical Research in Space

Category: Instruments and service infrastructure
Host institution(s): Lucerne University of Applied Sciences and Arts and University of Zurich, Space Hub
Main funding sources: Third party funding
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The University of Zurich, Space Hub, together with the Center of Competence in Bioscience and Medical Engineering (CC BME) of the Institute of Medical Engineering at the Lucerne University of Applied Sciences and Arts (HSLU), maintain the research infrastructure called "National Centre for Biomedical Research in Space" (NCBRS). The unique centre allows easy and uncomplicated access to low-gravity research platforms for scientists, industry, and students. The NCBRS is regarded as a ground-based facility for biological and medical space experiments. In this capacity, it offers its instruments and platforms to researchers from all over Europe to conduct experiments under simulated microgravity and partial gravity conditions. In addition, the NCBRS encourages microgravity research among scientists, companies, and schools in Switzerland.

Detailed description
The core service of the NCBRS provides access to several types of ground-based microgravity research platforms such as the Random Positioning Machine (RPM), parabolic flights, e.g. performed by the Swiss Air Force, and sounding rockets. We intend to expand our services over time through additional microgravity research platforms like magnetic levitation, drop towers (through their operators), or flights with space carriers of Space Applications Services or Virgin Galactic, for example.

In addition, the NCBRS services include biological laboratories and dedicated e-infrastructures. The laboratories are particularly useful to scientists investigating time-critical processes that require immediate post-processing after microgravity exposure. The e-infrastructure is intended to create a permanent service data infrastructure serving the operatinonal needs for intensive data production under simulated and short-term microgravity conditions. The aim is also to establish a flexible, extensible state-of-the-art service infrastructure that can provide support over the entire science work cycle.

The NCBRS is a non-profit centre available to everyone interested in conducting biomedical research in a reduced gravitational environment. In addition, an outreach programme is in place to gain maximum visibility to the related scientific community and the public.

b. International level
In 2000 the former Space Biology Group of ETH Zurich (which is now the CC BME) was selected as one of the few official ground-based facilities of the European Space Agency ESA. Since then, we have evolved into the NCBRS and hosted international research groups, enabling them to conduct their studies multiple times a year. Besides having our services paid by the users, we also benefit from their publications in scientific journals and presentations at symposia or conventions. Maintaining the NCBRS and expanding the services further will attract even more researchers wishing to conduct experiments in our centre.

c. Development prospects
The RPM is a frequently used instrument in laboratories all over the world and it is used to investigate microgravity effects on biological systems, among other things. Its intense use is reflected in the steadily increasing number of reports published yearly in scientific journals. The NCBRS thus aims to provide enough RPMs for the scientists.

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

d. Costs (in CHF m)

2021–2024		2025–2028		2029–2032	
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	ESA/users: 0.15	Third parties	ESA/users: 0.20	Third parties	ESA/users: 0.25
Total budget	**0.15**	**Total**	**0.20**	**Total**	**0.25**

Costs overview (2021–2024)		2025–2028		2029–2032	
Investments	0.02	Investments	0.05	Investments	0.05
Operating costs	0.13	Operating costs	0.15	Operating costs	0.20
Other costs	0	Other costs	0	Other costs	0
Total costs	**0.15**	**Total**	**0.20**	**Total**	**0.25**

Development Phases	Years
Design	2015–2016
Preparation	2016–2017
Implementation	2017–2019
Operation	2020–2032

13. Swiss Ultrahigh-field-NMR Facility

Category: Instrument
Host institution(s): University of Zurich, ETH Zurich, University of Basel
Main funding sources: Cantonal Funding, ETH Zurich
Roadmap entry: 2019

Description / Development prospects
a. National level
Overview
A national High-Field Solution NMR spectroscopy facility will be established to propel Switzerland's outstanding position as a leading country in NMR spectroscopy. The national facility would be located at the Irchel Campus of the University of Zurich (1.2 GHz instrument), operated by UZH's Department of Chemistry, and UNIBAS's Biocentre (800 MHz Instrument). The facility will be jointly managed by the three partnering institutions. Funding comes from University of Zurich, ETH Zurich and University of Basel. Access to the facility will be open to research groups and industrial partners in Switzerland. Data from the new spectrometer should greatly improve Swiss biomedical research.

Detailed description
The 1.2 GHz NMR instrument will greatly improve experimental sensitivity and resolution for analysis of biomolecules. The magnet uses pioneering 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 will be studied by groups at the host institutions and by many other Swiss research groups. Applications include studies of structure, function, dynamics and folding of biomacromolecules incl., 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 include the development of drugs and new high-resolution NMR methods. The generated data will bring key insights into key biological mechanisms, e.g. protein biogenesis, signalling, allosteric regulation, catalysis, RNA regulation and splicing, and epigenetics in normal and pathogenic biomolecular systems.

Many biologically relevant targets are in a size-range that tremendously benefits from the increased sensitivity of high- and ultrahigh-field NMR instruments. Together with an 800 MHz instrument, used for sample characterisation and validation, the new 1.2 GHz instrument will improve NMR research nationally, thereby contributing to the competitiveness of biomedical research in Switzerland. Moreover, it will help to recruit top scientists in these biomedical fields to Swiss universities or research institutions and complement the existing NMR centres at the ETH Zurich (500 – 900 MHz), University of Basel (500 – 900 MHz), EPF Lausanne (400 – 800 MHz), and University of Zurich (500 – 700 MHz).

b. International level
At the European level, 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 Europe, large NMR facilities exist in the US, Canada, Japan, China, Australia, Brazil, India, Russia, Saudi-Arabia, and Taiwan. Switzerland is a world leader in solution Bio-NMR. The situation will change once 1.2 GHz solution NMR becomes available. Several machines have been ordered by institutions in Germany (Munich, Berlin, Frankfurt, Göttingen, Jülich), Netherlands (Utrecht), Italy (Florence), France (Lille), US (Memphis), UK and Korea.

Swiss High-Field Solution NMR will also develop ties with INSTRUCT in structural biology in the European Strategy Forum on Research Infrastructures (ESFRI) to foster scientific exchange.

c. Development prospects
Solution NMR has greatly advanced structural biology, solving structures of many < 30 kDa proteins. It has been used extensively to probe interactions between drugs and receptors, and thereby critically contributed to development of many drugs. NMR is uniquely capable of probing the dynamics of and between biomolecules, which is key to enzymatic function. This has been extensively researched and will continue to be crucial even though most structures or folds have been unravelled. Ground-breaking work has been done on ribosome function, proteasome megadalton protein assembly involved in protein degradation, the entire catalytic cycle

of dihydrofolate reductase - a pharmaceutically highly relevant protein, or on 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 or small-angle X-ray scattering 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 highly medically relevant pathogenic proteins is involved in neurodegenerative diseases, many belonging to intrinsically unfolded proteins. For all the above-mentioned systems access to High- and Ultrahigh-Field NMR spectrometers will be essential.

Biomedical research is moving into the systems biology field, in which interactions between complex biomolecular systems are studied. Again, the systems will be much more amenable to a detailed analysis with data of increased resolution as available from an Ultrahigh-Field NMR spectrometer. Finally, the hardware developments are made by a market-leading company based in Switzerland/Germany. Investigating into high-end products will thus encourage further developments and research in this cutting-edge technology and help in securing Switzerland's role as a major player in high-tech industry.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution UniBasel/UZH 10.80		Higher Education Institution	5.00	Higher Education Institution	5.00
Canton	0	Canton	0	Canton	0
Swiss Confederation ETHZ 6.00		Swiss Confederation	0	Swiss Confederation	0
Third parties	1.20	Third parties	0	Third parties	0
Total budget	**18.00**	**Total**	**5.00**	**Total**	**5.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	16.00	Investments	1.00	Investments	1.00
Operating costs	2.00	Operating costs	4.00	Operating costs	4.00
Other costs	0	Other costs	0	Other costs	0
Total costs	**18.00**	**Total**	**5.00**	**Total**	**5.00**

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

14. Swiss Research Network of Clinical Paediatric Hubs (SwissPedNet)

Category: Service infrastructure (Data / Service Centres: Clinical research specific services)
Host institution(s): Mainly hospitals
Main funding sources: Host institutions, SERI
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
SwissPedNet is a nation-wide research organisation consisting of clinical pediatric hubs located at the nine largest (university) pediatric hospitals in Switzerland, a central coordination office at the Swiss Clinical Trial Organisation (SCTO), a central infrastructure for registries (SwissPedRegistry), and the research infrastructure providing services in pediatric pharmacology (SwissPedPha). Each pediatric hub has age- and development-adequate infrastructures (clinical facilities for children) and is staffed with pediatrics-trained personnel, guaranteeing the quality aspects for clinical research in children.

Detailed description
SwissPedNet promotes, facilitates, coordinates and conducts clinical trials devoted to children ranging from newborns to adolescents, in all pediatric disciplines. SwissPedNet enhances clinical research in pediatrics both by helping pediatric clinician scientists to engage in high-quality clinical research and by encouraging an overall increased acceptance for clinical trials in children in the community. While being dedicated to children, the clinical pediatric hubs are locally closely linked to the SCTO Clinical Trial Units (CTUs) network, sharing non-pediatric-specific aspects of clinical research with the corresponding facilities for adults. The central office of the SwissPedNet is located within the SCTO Executive Office.

SwissPedNet is the official partner for clinical research of «pädiatrie schweiz». Several large scale national interventional trials launched from within SwissPedNet and utilising PedNet hub infrastructure have been completed (Swissped-Recovery), are currently running (KIDS-STEP) or are about to start (MyTHIC). These trials have the potential to influence international medical management guidelines and directly raise the profile of Swiss pediatric clinical research nationally and internationally. SwissPedNet supports the work of research associates and pediatric research nurses at each hub, thereby safeguarding compliance with Good Clinical Practice (GCP) and assuring common practice and comprehensive implementation of all safety and quality maintenance procedures of clinical pediatric research. To ensure optimal integration of early career clinical researchers in pediatrics, SwissPedNet offers the "Next Generation" training programme.

SwissPedNet also develops, professionalises and strengthens national structures (SwissPedRegistry, SwissPedPha). Key tasks of SwissPedPha are to improve the quality of designs of pediatric pharmacological studies conducted by SwissPedNet and to optimise analyses of resulting data. SwissPedRegistry provides expertise and advice for the development and conduct of registry-based research, focusing on health-related data collection for diseases particularly affecting children and adolescents.

SwissPedNet co-applied to the SPHN Datastream call and is now supporting and serves as the critical link to enable embedding of clinical research within routine practice through the use of routine data from SwissPedNet hubs.

b. International level
SwissPedNet is member of Enpr-EMA, the European Network of Paediatric Research at the European Medicines Agency with its main objective to facilitate studies in order to increase the availability of authorised medicines for children.

SwissPedNet is a 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, implementation and evaluation of robust, sustainable and integrated pan-European network trial delivery.

The high quality enabled by SwissPedNet has resulted in SwissPedNet hubs being selected for a number of high-profile randomised controlled trials supported by European funding, including trials in pediatric emergency care and neonatal intensive care.

c. Development prospects

The current funding of CHF 4'704'000 – divided into 4 annual contributions of CHF 825'000, 1'252'000 and twice 1'300'000 – during the funding period 2021 to 2024, enables the hubs to employ 0.8 to 1.0 FTE to support clinical research nationwide. This allows the hubs of our network to initiate and conduct nationwide and international clinical studies and participation in high-impact international clinical trials.

SwissPedNet turns the relative weakness of a relatively limited size of the source population into a strength by centrally coordinating close collaboration between its hubs. A number of smaller cantonal pediatric wards (e.g. Fribourg or Chur) would benefit from joining SwissPedNet as this would improve their capacity to conduct clinical research. This in turn would ensure innovative and impactful clinical research targeting pediatric diseases with a limited patient population and would stimulate international interest to partner with SwissPedNet in pediatric research. To enable new hubs to join SwissPedNet, additional funding of CHF 300,000 to CHF 400,000 /funding period is needed.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution Host institutions of members: 7.20		Higher Education Institution Host institutions of members: 7.00		Higher Education Institution Host institutions of members: 7.00	
Canton	0	Canton	0	Canton	0
Swiss Confederation SERI (SCTO[48]): 4.70		Swiss Confederation SERI (SCTO[49]): 5.00		Swiss Confederation SERI (SCTO[50]): 5.00	
Third parties	0	Third parties	0	Third parties	0
Total budget	**11.90**	**Total**	**12.00**	**Total**	**12.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0	Investments	0	Investments	0
Operating costs	11.90	Operating costs	12.00	Operating costs	12.00
Other costs	0	Other costs	0	Other costs	0
Total costs	**11.90**	**Total**	**12.00**	**Total**	**12.00**

Development Phases	**Years**
Design	2013–2016
Preparation	2017–2020
Implementation	2021–2025
Operation	2021–2029

48 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 17.2 million for 2021–2024 (Art. 15 RIPA) and allocated CHF 4.704 million to SwissPedNet.

49 The SCTO will apply for CHF 23.08 million for the 2025–2028 funding period (Art. 15 RIPA) and plans to allocate CHF 5.00 million to SwissPedNet. Numbers may change as the proposal has not yet been submitted.

50 The SCTO plans to allocate CHF 5.00 million to SwissPedNet from the funding it receives under Art. 15 (RIPA) in 2029–2032 (unknown).

15. Swiss Center for Musculoskeletal Biobanking and Imaging and Clinical Movement Analysis (Balgrist Campus)

Category: Technology Competence Centre
Host institution(s): Balgrist Campus AG
Main funding sources: Donations, SERI, rental income and user contributions
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The three open research platforms have been supported by SERI since 2017 and were created within the Balgrist Campus research and development building. The Balgrist Campus is an international research building, in which 18 academic research groups from the University of Zurich and 3 from the ETH are based, together with start-ups and MedTech companies. For all research disciplines, the goal is to produce results which can be translated to patients as quickly as possible. The open research platforms Imaging (SCMI), Biobanking (SCMB) and Movement Analysis (SCMA) were built on time and on budget and have been in operation since 2019.

Detailed description
The combination of problem identification and analysis by clinicians and researchers with industrial problem-solving approaches in a university setting is unique. It remains the goal of the Balgrist Campus to host a wide range of research groups with national and international collaborations in musculoskeletal science to further advance translational research.

SCMA: The movement analysis was the last of the three platforms to be staffed and equipped in terms of infrastructure. The operational phase therefore began at a later date and platform operation is about 1 year behind the other two platforms.

SCMB: The biobank is developing according to budget. In addition, it has achieved the goal of certification and was awarded the highest "Optima Level" by the Swiss Biobanking Platform this year.

SCMI: Imaging is working at full speed both in the development of musculoskeletal MR and CT imaging, and in terms of its services (project mandates) and corresponding user revenues. However, even in the 4th operational year since the platforms were opened, the 7T-MRI can still not yet be used in the originally planned projects, due to equipment supplier delays. Only head and knee coils with appropriate clinical approval are available. SCMI is trying to make up for these shortfalls with contracts outside the musculoskeletal field (e.g., neurology, forensic medicine or psychology).

b. International level
On an international level, research collaborations and multi-center studies are the declared goal of the Balgrist Campus. Within the academic research groups, numerous EU projects are ongoing. As a technology competence centre, collaboration with industry is important. Since the very beginning, the collaboration with SIEMENS HEALTHINEERS has been central for our imaging platform SCMI and has been further strengthened this year: in addition to the 2 on-site scientists working on further development of the 7T-MRI for the musculoskeletal system, a CT device of the latest generation was delivered in May 2022 and again, the SCMI team will have an additional CT research position, which will be jointly funded by Siemens and the Balgrist Campus.

The Guest Sabbatical Programme at Balgrist Campus came to an end in 2021 with Prof. N. Navab (TU Munich) and the Balgrist Campus expects to welcome a new international group to the Balgrist Campus in the near future.

c. Development prospects
With its three platforms SCMA, SCMB and SCMI, the Balgrist Campus is currently in the consolidation phase: the amortisation of the infrastructure and the repayment of debt capital will be completed by the end of 2024. User contributions can be increased each year with the goal of covering approximately 50% of operating costs at the end of the reporting period (2024).

d. Costs (in CHF m)

2021–2024		2025–2028		2029–2032	
Higher Education Institution		Higher Education Institution	0	Higher Education Institution	tbd
UKB, UZH, ETH (rental contracts)	13.60				
Canton	0	Canton	0	Canton	tbd
Swiss Confederation		Swiss Confederation	0	Swiss Confederation	tbd
SERI (Art. 15 RIPA)	15.70				
Third parties		Third parties		Third parties	tbd
Business coop. (rental income)	0.25	Platform revenues	5.00		
Platform revenues (user contr.)	2.30	Own resources (incl. 3rd party)	5.60		
Balgrist-Stiftung (research)	0.25				
Own resources	0.70				
Total budget	**32.8**	**Total**	**10.60**	**Total**	**tbd**

Costs overview (2021–2024)		2025–2028		2029–2032	
Investments		Investments	1.00	Investments	tbd
Impairment/repayment of debt	8.00	Operating costs	9.60	Operating costs	tbd
Operating costs		Other costs	0	Other costs	tbd
Personnel	8.20				
General operating expenses	10.10				
Other costs					
Provisions, amortizations	6.50				
Total costs	**32.80**	**Total**	**10.60**	**Total**	**tbd**

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

16. Neuchâtel Platform of 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), SNSF
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
The Neuchatel Platform for Analytical Chemistry (NPAC) was created in 2014 as the result of a merger between the Uni NE chemical analytical facilities and the chemical analytical service of the *Swiss Plant Science Web*. NPAC now provides chemical analytical services for all Swiss universities, federal research institutes and industries. The aim is to expand the platform so that it becomes a leading centre for chemical analytics and metabolomics both in Switzerland and around the world. 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 Neuchatel currently performs more than 20'000 analyses per year and greatly facilitates the research of scientists and industries throughout Switzerland and beyond. The platform uses state-of-the-art liquid (LC) and gas (GC) chromatography, mass spectrometry (MS), and nuclear magnetic resonance spectroscopy (NMR) in order to support research on the isolation, characterisation, identification and quantification of small bioactive molecules of scientific and practical interest. We wish to further develop the NPAC facilities and expand the platform to become one of the world's leading centres for 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 environmental protection. 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. In the context of the NCCR Plant Survival, the University of Neuchâtel has greatly contributed to these recent developments at 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. In the recent years, NPAC has established collaborations with researchers from several European countries as well as the US and Australia. Hence, NPAC is already recognised worldwide as one of the top analytical services.

c. Development prospects
Below we indicate the commitment by UniNE and the additional funding that we expect to obtain from other sources (SNSF, industries etc.). Since the Roadmap 2015, the University of Neuchatel has fully honoured its commitments.

For the funding period 2015 – 2018, the following investments were made:

- 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)

For the funding period 2019 – 2022, the following investments have been made:

- Appointment of a second technician (80%) in 2019 (UniNE funding)
- Appointment of a scientific collaborator (100%) in 2021 (UniNE funding)
- Purchase of a 600 MHz NMR in 2019 (CHF 800'000, UniNE funding)

- Purchase of a second gas chromatography-mass spectrometry system (CHF 235'000) in 2019 (ERC grant funding)
- Purchase of a proton transfer reaction mass spectrometer (CHF 380'000) in 2019 (ERC grant funding)
- Purchase of a UHPLC-high resolution MS in 2020 (CHF 620'000, UniNE+SNF R'Equip)
- Purchase of a triple quadrupole MS in 2021 (CHF 235'000, UniNE funding)
- Purchase of a UHPLC system in 2022 (80'000 CHF, BAFU funding)

For the next funding period, further equipment purchases will be based on replacing obsolete equipment, as well as on future commercially available technological breakthroughs. In particular, we plan to buy a new high-resolution mass spectrometer with novel features (Zeno-TOF). Finally, we intend to hire a bioinformatics specialist to reinforce the capabilities of our facility.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	1.59	Higher Education Institution	1.20	Higher Education Institution	1.20
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	0
Third parties	0.08	Third parties	0.60	Third parties	0.60
Total budget	**1.67**	**Total**	**1.80**	**Total**	**1.80**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	0.47	Investments	0.60	Investments	0.60
Operating costs	1.20	Operating costs	1.20	Operating costs	1.20
Other costs	0	Other costs	0	Other costs	0
Total costs	**1.67**	**Total**	**1.80**	**Total**	**1.80**

Development Phases	**Years**
Design	2013
Preparation	2013–2015
Implementation	2015–2028
Operation	2015–2032

17. 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, and ETH Zurich
Main funding sources: Structural funds by participating universities and associated university hospitals, contributions by large scale research projects; State Secretariat of Education, Research and Innovation (SERI)
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
BioMedIT (biomedit.ch) is a nationwide and centrally coordinated distributed network of core facilities that provide secure computational infrastructures, services and competences for research in Switzerland. The project builds on existing expertise and research infrastructures in the partnering institutions by extending their capacity and capabilities. BioMedIT is managed by the Swiss Institute of Bioinformatics (SIB) and is tightly integrated with the activities of the Data Coordination Center of the Swiss Personalized Health Network (SPHN) initiative of the Confederation. While implementation is driven by biomedical applications, the resulting secure network also has a broad range of applications for the sharing and processing of sensitive data beyond the field of life sciences.

Detailed description
Biomedical research using personal data from citizens and patients is subject to extensive requirements in terms of 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 data-driven medical research approaches, especially in the context of SPHN and PHRT. By establishing mechanisms enabling nationwide exchange of health-related data, SPHN will also allow the secondary use of health data for research. BioMedIT was established as a nation-spanning, distributed network, providing secure computational infrastructure, services, and competences for biomedical research in Switzerland. It enables health data to be captured, processed and used for analyses of big data, ML/AI and other research approaches. The high-performance computing and storage infrastructure spans three major Swiss research institutions: SIS at ETH Zurich, sciCORE at the University of Basel, and SENSA at the University of Lausanne. In 2022, the responsibility for SENSA has been transferred from SIB to the University of Lausanne, with shared usage of the node infrastructures and a close collaboration between Unil and SIB. All three nodes employ modern cloud technology and cutting-edge security procedures, offering ICT services to researchers and research consortia affiliated with bona fide, Swiss academic research institutions. Additional, specific software and data projects are performed decentrally at various partner sites, depending on the local technical and scientific competences.

The three nodes operate their infrastructures under one Information Security Policy and based on common standards for IT security. They also apply common mechanisms for secure data exchange between hospitals and research institutions, and provide interoperable software and data analysis workflow execution capabilities across the network. National collaborations include the five university hospitals, swissuniversities, SDSC, SWITCH and the ETH domain & PHRT platforms on management and processing of omics data for personalised health research. BioMedIT is managed by the Personalized Health Informatics Group of SIB under the responsibility of the BioMedIT Board, and coordinated by the SPHN Data Coordination Centre. Working groups on "IT Security", "Interoperability" and "Research Support" directly support the nodes as well as researchers, work on the scalability and sustainability of the network and provide guidelines for future developments.

b. International level
An initial project with international participation (University of California San Francisco) has been running on BioMedIT since April 2022. Moreover, one BioMedIT node (sciCORE) acts as a Swiss station for a global Personal Health Train project for federated learning in collaboration with partners in the Netherlands and over 30 stations worldwide. In addition, the BioMedIT team and its partners are actively participating in international collaborations such as the ELIXIR Converge program (for EGA and container execution work packages) and the Elixir Biohackathon (Explore mapping of GA4GH Phenopackets

and SPHN RDF Schema). Moreover, the BioMedIT team actively contributes to GA4GH (in the Cloud, Security & Discovery workstreams and in exchange with the Clinical & Phenotypic Data Capture workstream).

c. Development prospects

While the main focus of the first phase of BioMedIT was on establishing a distributed infrastructure layer for a "Trusted Research Environment", the second phase of BioMedIT is focused on the further development of the ICT infrastructure and central services for multi-site, data-driven research projects. This includes an extension beyond the original set of partner hospitals to include health information from other data providers, with a view to inclusion of healthy citizens (e.g., longitudinal cohort studies), large scale *omics projects (e.g., SPHN National Data Streams) and the development of a Federated EGA as national repository for genomics and phenotypic data.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	11.10	Higher Education Institution	1.50	Higher Education Institution	1.50
Canton	0	Canton	0	Canton	0
Swiss Confederation	SERI (Art. 15): 18.50	Swiss Confederation	within the framework of the Future DCC: 1.50	Swiss Confederation	within the framework of the Future DCC: 1.50
Third parties	1.50	Third parties	1.00	Third parties	1.00
Total budget	**31.10**	**Total**	**4.00**	**Total**	**4.00**

Costs overview (2021–2024)		**2025–2028**		**2029–2032**	
Investments	6.00	Investments	0.50	Investments	0.50
Operating costs	25.10	Operating costs	3.50	Operating costs	3.50
Other costs	0	Other costs	0	Other costs	0
Total costs	**31.10**	**Total**	**4.00**	**Total**	**4.00**

Development Phases	**Years**
Design	2017
Preparation	2017
Implementation	2018–2024
Operation	2025–2032

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

Category: Information and service infrastructure
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.
Roadmap entry: 2015

Description / Development prospects
a. National level
Overview
SWITCH is a foundation of Swiss universities, whose mission is to provide outstanding information and communication services (e-infrastructures) to the research and education community. The e-infrastructure of SWITCH consists of three principal parts, which complement each other in an ideal way: SWITCHlan is the physical network layer, SWITCHengines is the infrastructure layer and SWITCH edu-ID is the identity and access layer. As such, SWITCH has moved towards an integration of networks, cloud infrastructure and ID/access services and continues to improve its functionality.

Detailed description
SWITCHlan: As a physical link, SWITCHlan brings together universities and research institutions from all over Switzerland (www.switch.ch/network/). SWITCH has built this Education and Research Network (NREN) on its own and is constantly developing it. Stable Internet access, the rapid and secure exchange of data at up to 100 Gigabit/second and an excellent connection to international networks – SWITCH offers all of this. Recently a SCION-service has been added to the SWITCHlan service portfolio. In addition, a research-driven frequency distribution service has been implemented. Our NREN provides the high-quality communication infrastructure required for cooperation and exchange across national borders and optimal connection of institutions worldwide. To protect the network and the sharing of scientific information, SWITCH runs a computer emergency response team (CERT) that has developed into a national cybersecurity competence centre and is continuously expanding its services. Besides the expanded CERT services, SWITCH provides managed security services (MSS), security awareness services and more.

SWITCH edu-ID: Today, SWITCH edu-ID is the basis for the federated identity management of the education sector in Switzerland, which has been managed by SWITCH in coordination with universities since 2000. Since 2016, SWITCH has been transforming the predecessor serivce SWITCHaai to today's user-centric identity management system SWITCH edu-ID that puts the user at the centre. This user-centric identity enables greater mobility and is intended to facilitate lifelong learning. In this regard, SWITCH works not only with Swiss universities, but also with libraries and other partners nationally and internationally. With over 750,000 accounts, the SWITCH edu-ID is now widely used in higher education. Data protection and user self-determination are key features of SWITCH edu-ID.

SWITCHengines: The infrastructure 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 can serve the special needs and national regulations for academic computing and information management. SWITCH will offer its cloud infrastructure to the research community - in balance with e-Science- and IT-teams of universities. At present, its components are located in Zurich and in Lausanne.

b. International level
SWITCHlan: At international level, SWITCH is involved 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. The European Union (EU) subsidises GEANT as an integral part of Horizon Europe.

SWITCH edu-ID: International collaboration is a fundamental requirement of the Swiss education, research and innovation sector supported by SWITCH edu-ID. As part of the GÉANT organisation and project, which is supported by the EU, users can also access international services by means of SWITCH edu-ID.

c. Development prospects

SWITCHlan: SWITCH is currently about to introduce 400 Gbps-technology in the IP-layer because of constantly growing capacity needs of connected institutions. Within the next funding period 2025–2028, the network will renew the optical network layer. At international level, SWITCH will continue to participate in the GÉANT projects through Horizon Europe, currently contributing to GN5-1 and planning for the upcoming GN5-2 (2024 onwards). The focus will be on powerful and resilient network access to European and worldwide NREN with a terabit networking option driven by elevated communications needs of distributed HPC infrastructures. Concerning security services, SWITCH is further developing the competence centre with a focus on SWITCH Community-SOC and security awareness services.

SWITCH edu-ID: By 2025, SWITCH edu-ID will transition from a user-centric to a self-sovereign identity in the federal government's future e-ID ecosystem. Thus, it will become the sector identity for Swiss education, research and innovation. Thus, SWITCH will give universities top-notch support for the future e-ID ecosystem and international equivalents.

SWITCH Cloud: SWITCH intends to migrate existing SWITCHengines Services to a new Cloud Platform called SWITCH Cloud and move to a new Data center between now and 2025. With this step SWITCH will be able to provide a certified Cloud Infrastructure with a high level of trust and governance to operate and store very critical datasets. SWITCH Cloud is a strategic sourcing option for research institutions and universities.

d. Costs (in CHF m)

2021–2024		**2025–2028**		**2029–2032**	
Higher Education Institution	55.00	Higher Education Institution	60.00	Higher Education Institution	60.00
Canton	0	Canton	0	Canton	0
Swiss Confederation	0	Swiss Confederation	0	Swiss Confederation	0
Third parties	0	Third parties	0	Third parties	0
Total budget	**55.00**	**Total**	**60.00**	**Total**	**60.00**

Costs overview (2021–2024)		2025–2028		2029–2032	
Investments	6.00	Investments	8.00	Investments	6.00
Operating costs	31.50	Operating costs	33.50	Operating costs	34.50
Other costs	17.50	Other costs	18.50	Other costs	19.50
Total costs	**55.00**	**Total**	**60.00**	**Total**	**60.00**

Development Phases	**Years**
Design	2019–2022 (depending on service)
Preparation	2020–2024 (depending on service)
Implementation	2022–2026 (depending on service)
Operation	2024–2028 (depending on service)