Research Infrastructures in Switzerland

Reflexion and discussion paper

(Approved by the SNSF Presiding Board)

20 September 2023

Content

Executive Summary

Access to quality research infrastructures has become essential for public and private research stakeholders.[1] Infrastructures developed to respond to the needs of research in diverse fields are central for the acquisition of knowledge and for innovative technological development. They thus have a vital role to play in the advancement of science and the resolution of global challenges. This role depends however on their long-term existence and on their capacity to continuously adapt to researchers' needs.

In Switzerland, the home of some world-class infrastructures, the research infrastructure landscape is fragmented, heterogeneous and geared to short-term funding cycles. As research infrastructure projects become increasingly complex and expensive, there is a need for coordinated strategic planning and long-term funding models that will ensure scientific excellence, facilitate international collaboration and support interdisciplinary research and innovation in accordance with Open Research Data principles.

The State Secretariat for Education, Research and Innovation (SERI) prepares a National Roadmap for Research Infrastructures every four years in collaboration with major players in the ERI domain. Nonetheless, establishing a coherent and coordinated system presents a major challenge as funding sources are diverse and coordination between the ERI actors is not yet achieved.

Considering the review of the National Roadmap process initiated by SERI in May 2023 as an opportunity to rethink the system for funding research infrastructure in Switzerland, the SNSF puts forward a possible model for discussion. It proposes the establishment of a new national body composed of representatives from the ERI domain and the Confederation; this would be responsible for the long-term strategic planning, management, coherence and sustainability of research infrastructures. The aim is to create an integrated research infrastructure landscape consisting of mutually complementary and interconnected infrastructures, with coordinated and transparent decision and funding processes, and with an emphasis on data sharing and support for interdisciplinary/transdisciplinary research. This landscape would be linked to international infrastructures.

Long-term strategic planning would make use of a continuously updated long-term roadmap drawn up by the national body, based on an inventory of the existing structures and an evaluation of the present and future needs of the various scientific communities in collaboration with the ERI actors. Criteria adapted to the different types of research infrastructures and their life cycles could be used for the evaluation of the infrastructures in view of funding and to monitor their coherent development, and the quality and competitiveness of their services.

Funding could be channelled into the infrastructures within the current legal framework, but roles need to be clarified and the financial flows transparent. In parallel to the preparation of the four-year ERI Dispatch the research organisations would define their indicative medium-term financial framework to enable decisions on priority areas for investment at the national level. This would also achieve flexibility for the medium-term integration of infrastructures whose development cycle is not modelled on the four-year ERI Dispatch.

The proposed model could be implemented within the current legal framework. With a mandate from the Confederation, the ERI actors could set up the national coordination body with a view to preparing for the 2029-2032 funding period. An initial roadmap could form the basis for evaluating infrastructure proposals by the second half of 2026 while still integrating current processes, such as the development of thematic roadmaps or the work of the ORD Strategy Council.

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[1] OECD (2019), "Reference framework for assessing the scientific and socio-economic impact of research infrastructures". OECD Science, Technology and Industry Policy Papers, No 65, OECD Publishing, Paris, https://doi.org/10.1787/3ffee43b-en

1   Introduction

Research infrastructures play a vital role in advancing scientific knowledge, promoting innovation, addressing complex problems, and supporting economic and societal development. They are essential tools, equipment, services and facilities for researchers for conducting cutting-edge research across all fields, advancing scientific knowledge and having a broad and lasting impact on society.

Research infrastructures enable scientists to explore new frontiers of knowledge, answer fundamental questions and make significant discoveries. They often facilitate international collaboration and promote the sharing of knowledge and resources, contributing to the advancement of science and the resolution of global challenges. This collaboration and access to advanced tools can lead to innovation, the development of new technologies and the creation of novel applications across industries. They can therefore benefit industry by providing a platform for research and development activities.

Many of today's scientific and societal challenges are highly complex and require interdisciplinary approaches. Research infrastructures provide a collaborative environment where experts from different fields can come together to tackle these challenges, such as climate change, public health crises and energy sustainability. In the age of big data, research infrastructures are essential for collecting, storing and analysing vast amounts of data generated in various scientific fields.

Research infrastructures often require significant investments in terms of funding, human resources and infrastructure maintenance. By pooling resources and coordinating efforts, research infrastructures can maximise the impact of research funding and ensure that resources are used efficiently.

And finally, but perhaps most importantly, they provide opportunities for training the next generation of scientists and researchers. Students and early-career researchers can gain hands-on experience with cutting-edge technologies and methodologies, preparing them for future roles in academia, industry or government.

1.1   Scope

The term 'research infrastructure' covers a broad spectrum of facilities, activities and services that are very different from one another. For the purposes of this document, we want to cover the activities that are primarily carried out to *enable* research, but which cannot be considered as research insofar as the aim is not to answer a question or generate new knowledge. In this context, we also exclude from the definition the funding and management of research activities.

In 2013, the European Union proposed the following definition:[2]

> 'Research Infrastructures' means facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, for example for education or public services. They include major scientific equipment or sets of instruments; knowledge-based resources such as collections, archives, or scientific data; e-infrastructures such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to

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[2] Article 2 (6) of the Regulation (EU) No 1291/2013 of 11 December 2013: `Establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014- 2020)`. This definition is used by the European Strategy Forum on Research Infrastructures (www.esfri.eu/research-infrastructure-ri)

achieving excellence in research and innovation. Such infrastructures may be 'single-sited', 'virtual' or 'distributed'.

We consider the fact that an infrastructure may be specialised in a certain field, but this does not imply that its user community is restricted: an infrastructure must be able to support interdisciplinary research and innovation without restriction.

We also consider not only the problems of the infrastructures themselves but also their environment, which can be complex:

− For example, the definition allows research infrastructures to be grouped together under a single organisation. In Switzerland, in the social sciences, FORS, as well as developing a range of research services, hosts several longitudinal studies, each of which can be considered a research infrastructure. Some of these studies are also national components of European (ERIC) or international studies.

− The use of research infrastructures can be linked to Switzerland's participation in international research organisations in charge of the infrastructures and associated services (e.g. ECORD/IODP, ICDP, CERN, SKAO, ESO), or the Swiss nodes of international infrastructures (e.g. in ERIC infrastructures).

− Specific funding programmes can be organised in relation to infrastructures or groups of infrastructures (e.g. FLARE, see above), or in relation to experiments that will be carried out over the long term, as in the case of space missions (e.g. MARVIS[3]).

As a first attempt to bring coherence and a common understanding of the nature of research infrastructures in the Swiss ecosystem, we propose a classification system based on the functions of research infrastructures, inspired by the work of Hallonsten:[4]

− **Instruments**: Technological systems for experimentation and measurement (synchrotrons, high-performing computer resources, microscopy facilities, etc.)

− **Observatories**: Technologies for studying real-world phenomena (astronomical observatories, atmosphere observations and measurement technology, etc.)

− **Repositories**: Collections of data or material for research purposes (databases, biobanks, longitudinal studies, etc.)

− **Vessels**: Facilities enabling research work at remote locations (space missions, polar regions, oceans, etc.)

− **Services**: Coordination platforms offering know-how for harmonisation and state-of-the-art practices in research (in domains such as biobanking, clinical research, ORD, etc.)

This classification should allow for certain particularities, for example in terms of development phases and models, organisation and funding methods, or evaluation criteria (selection or monitoring during the life cycle). Infrastructures may encompass several categories (or functions), and each of them should be evaluated with specific criteria within phases of their specific life cycle. This is important to ensure that one single system can steer the whole spectrum of organisations, facilities or activities which fall under the definition of research infrastructure given above.

The elements presented in this document are intended to cover all research infrastructures of particular importance at the national level that offer a service to the entire scientific community in Switzerland. This document does not cover issues relating to the funding of scientific equipment for and by research

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[3] MARVIS – Space research with the SNSF (link)

[4] Hallonsten, O. (2020). Research Infrastructures in Europe: The Hype and the Field. *European Review, 28*(4), 617-635. doi:10.1017/S1062798720000095. (link)

organisations, although here too, for reasons of economy and sustainability, a coordinated effort should be made. While type should not be a criterion, the size and duration of development and operation of infrastructures should be subject to a threshold that justifies treatment at the national level.

1.2   Research Infrastructures in Switzerland and Legal Basis

Switzerland is home to world-class facilities such as CERN and contributes to major international networks, particularly through measurement facilities in the Alps. As a country focused on research and innovation, it has developed a special relationship with research infrastructures. Approximately CHF 1,775 million was invested per year in the funding period 2021-2024 for organisations, projects or activities considered as research infrastructures, which stresses their importance for research and innovation, at both the national and international level[5]. However, the most significant developments in the field of research infrastructures have been marked by the growing importance of data and its interconnection, as well as with services outside research. Although a pioneer in the promotion of Open Research Data, Switzerland faces a high degree of complexity in developing its data infrastructures and has some catching up to do in this area.

In Switzerland, the support of research infrastructures is embedded in the law. Although only implicitly stated in the legal documents, the funding of research infrastructures in Switzerland is primarily the responsibility of the research organisations: the cantonal higher-education institutions and the ETH Domain.

At the federal level, the legal basis for the financing of research infrastructures in Switzerland is anchored in the Federal Act on the Promotion of Research and Innovation (RIPA[6]) and its ordinance (RIPO[7]). At the federal level, it requires the actors to complement each other but does not really define a clear division of roles. The Federal Council has the responsibility to ensure that federal funding for research and innovation is used in a coordinated and effective manner (Art. 41 para. 1 RIPA). It is allowed to coordinate research and innovation if cooperation cannot be achieved between the research actors (Art. 41, para. 2, RIPA). For costly research infrastructures, the Federal Council coordinates the Confederation's international research and innovation promotion with the planning of the ETH Domain and the coordinated policy of the universities (for particularly cost-intensive fields, Art. 41 para. 4 RIPA).

The Swiss Roadmap for Research Infrastructures[8] is the declared planning instrument for integrating the financing of infrastructures of national importance in the Education, Research and Innovation (ERI) Dispatch (Art. 41 para. 4 RIPA and Art. 55 para. 1-5 RIPO[9]). Since 2011, the State Secretariat for Education, Research and Innovation (SERI) has produced a (four-year) report for the Federal Council on the status and development of research infrastructures, with particular reference to large international research facilities and other internationally coordinated research infrastructures in which Switzerland is involved. The legal framework, though, does not provide any definition for a research infrastructure. So far, the national Roadmap process has been based on the European definition[10] of research

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[5] Estimation based on the ERI Dispatch 2021-24, the national Roadmaps for research infrastructures 2019 and 2023.
[6] RIPA: fedlex-data-admin-ch-eli-cc-2013-786-20150101-en-pdf-a.pdfasa
[7] RIPO: https://www.fedlex.admin.ch/eli/cc/2013/814/en
[8] Swiss Roadmap for Research Infrastructures https://www.sbfi.admin.ch/sbfi/en/home/research-and-innovation/research-and-innovation-in-switzerland/swiss-roadmap-for-research-infrastructures.html
[9] See section 3.1
[10] European definition of research infrastructures: https://www.esfri.eu/research-infrastructure-ri

infrastructures, which is applied in most countries and by the European Strategy Forum on Research Infrastructures[11] (ESFRI).

Further articles refer to the funding responsibility of research infrastructures (Table 1). Independent of RIPA, federal offices may also support infrastructures for their own purposes and those that have a strong link with research and are or may be used by researchers (e.g. Federal Office of Public Health with patient or citizens databases and sample collections, Federal Office of Meteorology and Climatology, MeteoSwiss, with data on climate).

	Responsibility	Research infrastructures (examples)
Art. 10 para 3 lit. c RIPA	**Swiss National Science Foundation (SNSF)** Support of research infrastructures that serve the development of fields of expertise in Switzerland and that are not in the remit of the higher-education institutions or the Confederation	Data infrastructures and services (FORS, DaSCH, SHCS, STCS), longitudinal studies in SSH, participation in international infrastructures (IODP, ICDP, ICOS) and coordination platforms (SBP, SCTO)
Art. 11 para 6 RIPA	**Swiss Academies of Sciences (a+)** Support for data collections, documentation systems, scientific journals, and publications that serve as infrastructures for the development of fields of expertise in Switzerland, not in the remit of the higher education institutions and SNSF	Editions, data collections (HLS, Dodis, Bernouilli letter exchanges), cryosphere observation networks, SwissCollNet
Art. 15 para. 3 RIPA	**Confederation** Support of non-commercial research infrastructures outside the higher-education institutions	Research infrastructures of national importance: Swiss 3R Competence Centre, Swiss Polar Institute, Solar Research Institute, Swiss Institute of Bioinformatics, Swiss Social Archives, Vitrocentre Romont
Art. 28 para. 2 RIPA	**Confederation** Support of the Swiss participation in international research infrastructures	CERN, CTAO, ILL, BBMRI-ERIC, ICOS-ERIC, CESSDA-ERIC
Art. 47 para. 3 LEHE	**Confederation** Support of infrastructures of national importance from the HEI domain	To be applied for HEI projects in the Roadmap 2023

Table 1: Responsibility for research infrastructures

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[11] ESFRI: https://www.esfri.eu

2 Towards a Sustainable Framework for the Support of Research and Innovation Infrastructures in Switzerland

In recent years, the actors involved in the evaluation and funding of research infrastructures in Switzerland have identified several shortcomings in policy and organisation. As an independent and neutral organisation, the SNSF is in direct contact with the Swiss scientific community through its Research Council. It is responsible for evaluating any proposal for scientific activities, from the shortest stay in a research institution abroad to complex projects such as national centres of excellence or major research infrastructures. It is internationally connected and plays an active role in research funding developments. Regarding research infrastructures, the SNSF funds several activities and conducts the scientific evaluation of national projects submitted under the Roadmap.

The review of the National Roadmap process initiated by SERI in May 2023 represents a unique opportunity for the community to fundamentally rethink the system for funding research infrastructures in Switzerland. The creation of the ORD Strategy Council at the beginning of 2022 also shows that national coordination on research policy issues can be put in place quickly.

In line with its strategic priorities, the SNSF hereby presents its vision for coherent, sustainable and effective support for research infrastructures.

2.1 Challenges

The Swiss research infrastructure landscape has grown historically, following the needs of research and numerous political – national or local – strategies, based on short- or mid-term planning and without a systematic long-term perspective. It does not result from a coherent, generally accepted and sustainable vision.

Research is evolving quickly, and new needs for research infrastructures keep occurring, given the expansion of inter- and transdisciplinary research. Collaboration with international infrastructures is also gaining in importance, as they allow some economy of means and access to specialised or similar research infrastructures or to services not existing in Switzerland. The non-association to the European Framework Programmes may have consequences for Switzerland's ability to participate in strategic planning discussions.

The crucial importance of data and the adoption of Open Research Data (ORD) principles has become central to research infrastructures and raises new challenges relating to the scope and nature of their tasks. There is growing pressure on academic research infrastructures to respond to societal issues and industry also shows interest in making use of them.

The resulting challenges in selecting and funding research infrastructures are multiple, and tackling them necessitates a thorough reflection on the roles and responsibilities of the actors involved:

- **Fragmented landscape and legacy**: Numerous research infrastructures are anchored at one or several institutions and not connected with each other or visible to each other, as the result of uncoordinated decisions. Funding was not based on long-term funding strategies, nor was it coordinated between the different stakeholders and scientific communities. The lack of any inventory of existing infrastructures also hampers the development and selection of new ones.

- **Heterogeneity and complexity**: Existing infrastructures are various in size, outreach, purpose, developmental phases and funding mechanisms, which makes their coordination and sustainable funding difficult.
- **International integration**: International integration is crucial for the development of Swiss research. Such integration may however lead to strong commitments to funding it over the long term and resolving complex legal issues. In some cases, the lack of defined financial responsibility may lead to hurdles in participating in international infrastructures.
- **Digitalisation and Open Research Data (ORD)**: Infrastructures generate and manage huge amounts of data, and digitalisation and Open Science principles have become essential aspects of infrastructure management. Infrastructures must align with the national ORD Strategy, while new infrastructures based on data, and applying methods of artificial intelligence to exploit and manage it, are emerging, thus generating new needs (scientific and financial). The growing importance of digitalisation in the field of infrastructure has also led to the creation of numerous infrastructures that are increasingly delocalised and geographically distributed. The link between research infrastructures and other data sources is also becoming more and more of a reality.
- **Interdisciplinarity, trans-disciplinarity and societal challenges**: Following the development of science and the increasing amount of data available, research infrastructures need to become more interdisciplinary. They also raise expectations in terms of answering societal challenges and need to respond to them. Industry also shows strong interest in collaborating with publicly funded infrastructures. This cooperation needs to be addressed.
- **Professionalisation**: Research infrastructures are complex, and their operation requires highly specialised competencies ranging from managerial to technical and data-related skills, all of which need to be developed. To follow the progress of each infrastructure towards its objectives, indicators of the infrastructure's performance are needed.

2.2   Vision

Consistent, transparent and sustainable infrastructure funding and management are crucial to maintaining Switzerland's competitiveness and developing its research and innovation leadership. Research infrastructure portfolio management must move away from overly restrictive historical concepts and take account of the most recent developments and challenges in research infrastructures.

2.2.1   Responsibility

A national body ensures the strategic management, coherence and sustainability of research infrastructures in Switzerland. Scientific excellence is an integral part of all its recommendations and decisions.

While remaining neutral regarding the various infrastructures and acknowledging that better coordination leads to better performance and encourages collaboration, this national body has the necessary skills and knowledge to coordinate, manage and develop the portfolio of research infrastructures in Switzerland. It is responsible for identifying, gathering and prioritising the needs of the scientific communities, integrating them into the existing landscape and international context, and formulating development proposals in strategic domains.

To guarantee coordination and transparency at the national level, the national body could be made up of representatives of the national players in the ERI domain, including the Confederation.

2.2.2   Strategic Planning

A research infrastructure landscape should be made up of mutually complementary and interconnected infrastructures, creating an integrated space that promotes data sharing and support for research, including interdisciplinary research. Such a space should be fully linked to public infrastructures not specific to research and to international infrastructures, to encourage trans-disciplinary approaches and the tackling of major societal problems.

A solid – and above all *unique* – strategic planning process needs to be put in place to coordinate the development of the Swiss research infrastructure landscape. Such a process must in particular:[12]

- Encourage user communities to prioritise their needs with a long-term perspective and ensure the highest level of scientific excellence. This task may cover activities such as the development of mid- and long-term strategic plans or development roadmaps.[13] Examples of good practices abroad, such as the identification of scientific challenges in large domains, may be used as inspiration to design processes adapted to the specific features of the Swiss system.
- Enable a high degree of coordination and the strategic selection of research infrastructures according to the needs of the scientific communities, the planning of their long-term sustainability and a forward-looking approach.
- Enable the wide range of needs of different communities and the infrastructures they develop and use to be considered in a differentiated way.
- Support the development of a coherent landscape of research infrastructures, not only with the active involvement of research institutions and stakeholders and integration into its national research and innovation eco-system, but also across other relevant national policies.
- Ensure that decisions are consistent over time, particularly when taking part in large-scale experiments.

Figure 1 shows a diagram representing the key elements of the strategic planning process and its interactions with the environment.

A **long-term roadmap** is the result of a long-term strategic planning process. It is a continuously updated public document that guarantees the transparency of the research infrastructure landscape, its funding and its development. It is based on the overview of the existing landscape (inventory of existing infrastructures and landscape analysis), a scientific and strategic evaluation of the needs and a prioritisation of investment domains in which stakeholders from the ERI domain are involved. It forms the basis for the development of proposals for new infrastructures and substantial updates, with a view to carrying out a scientific and strategic evaluation.

Strategic planning is based on an **overview of research infrastructures (inventory)** and **landscape analysis**. The inventory provides a structured overview of the landscape of infrastructures of national importance in Switzerland and of international infrastructures that are relevant to Swiss research. The landscape analysis aims to complete the inventory by comparing the current landscape with its

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[12] InRoad Policy Brief N° 2 (link)
[13] See for example the Roadmaps for research infrastructures drawn up in 2019 by the SCNAT.

development potential (development of new areas, extensions, gap analysis, synergies, but also closure of certain infrastructures). Both documents are updated regularly to encourage a dynamic approach.

The development of long-term strategic planning is based not only on an analysis of the landscape but also on an expression of research needs. There are various mechanisms for **identifying the infrastructure needs** of scientific communities, but a systematic assessment of this kind has not yet been introduced in Switzerland. In view of the latest Swiss Roadmap process, the Confederation has mandated SCNAT to develop and publish thematic roadmaps[14] in seven areas of the natural sciences by 2021. These documents formed a basis for drawing up the national roadmap but were not binding in terms of preparing applications or decision-making. Another example comes from the US Department of Energy, which mandated a group of scientists to write a series of reports[15] that summarise future challenges and opportunities. Every subsequent proposal or strategy submitted later in this domain will use elements of the report. Basically, proposals will respond to these challenges with solutions for working on them.

A **monitoring** system is set up by the national body in collaboration with the Swiss ERI stakeholders to ensure the coherent development of infrastructures and the quality and competitiveness of their services. The evaluation and performance criteria are adapted to the different types of infrastructure and services, and to the different phases in their life cycle, but they are harmonised across the whole of Switzerland to enable comparisons between services and infrastructures. Existing work from international organisations, such as the OECD or ESFRI, is integrated into the development of the monitoring system. As members of the national body, the organisations in charge of funding research infrastructures are responsible for collecting the monitoring information.

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[14] SCNAT - Roadmaps for research infrastructures (link)
[15] See for example Hemminger, J, Fleming, G, and Ratner, M. *Directing Matter and Energy: Five Challenges for Science and the Imagination*. United States: N. p., 2007. Web. doi:10.2172/935427. (link)
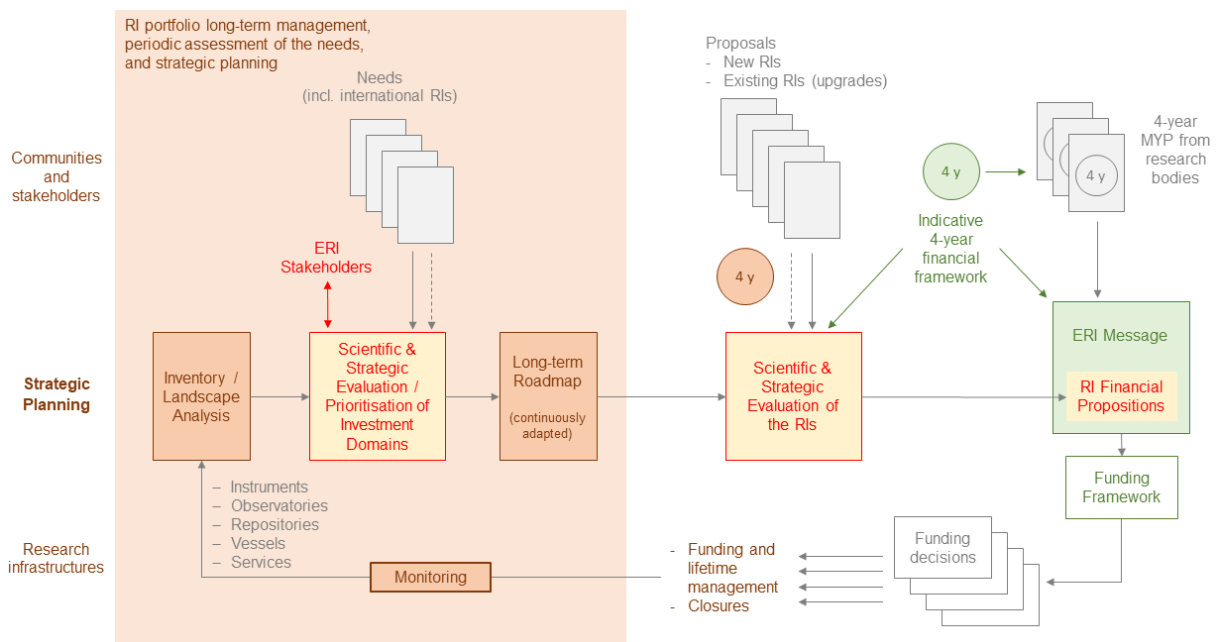
Figure 1 Proposed research infrastructure strategic planning process and funding. The strategic planning process managed and coordinated by a national body leads to regular updates of the long-term roadmap, based on the analysis of the research infrastructure landscape (including the monitoring of existing infrastructures) and the assessment of the needs of the scientific communities. The Long-term Roadmap forms the basis for the scientific and strategic assessment of funding proposals for new infrastructure or major upgrades.

2.2.3   Planning Process

Every four years, in their multi-annual programmes, the Swiss research bodies provide information on the research and innovation policy they are pursuing and the priorities they have set themselves for the medium term.[16]

Research infrastructures can have very different development cycles to the four-year period of the ERI Dispatch. The continuous updating of the long-term roadmap allows this document to adapt to the realities of infrastructure. Every four years, however, the roadmap is prepared for the process of evaluating and selecting infrastructures and updating them, with a view to drawing up the ERI Dispatch. This is an opportunity for the roadmap to point to the integration of infrastructures in the medium term whose development is not yet mature for the four-year deadline, or to deferred participation in international infrastructure, or to the planning of a substantial update linked to a major (technological or conceptual) change. It also contains indications of infrastructures that should be closed.

By covering these different aspects and highlighting the domains in which Switzerland should invest in the mid- and long-term (priority domains), the roadmap also serves as an indication for the development of the ERI stakeholders' multi-year plans.

New infrastructures must only be proposed in the priority domains and selected competitively. Every four years, the SNSF carries out a **scientific and strategic evaluation** to determine the basis for funding during the next four-year period, based on budgetary indications provided by the Confederation, the research organisations and the higher-education institutions (see Section 2.2.4).

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[16] Based on RIPA, art. 45

The **national body** is responsible for mechanisms designed to regularly:

- – Identify the needs of the communities and perform an assessment of the portfolio of Swiss research infrastructures and their services. It can propose potential changes such as mergers, closures, or ways to respond to newly expressed needs.
- – Carry out, in consultation with the stakeholders in the ERI domain, a scientific and strategic assessment of these needs, and prioritise investment domains on this basis, resulting in an update of the long-term roadmap.
- – Gather proposals for new infrastructures, Swiss participation in international infrastructures and major upgrades of existing ones (within their own, pre-defined life cycle).
- – Draw up a selection, based on the strategic and scientific evaluation of the infrastructures conducted by the SNSF, with a view to the preparation of the four-year ERI Dispatch.

2.2.4 Funding

The long-term roadmap contains information about the existing infrastructures and the basis for the competition for new infrastructures or major upgrades. Some infrastructures benefit from clearly defined funding (e.g. major infrastructures in the ETH Domain), but many must rely on different sources of funding, federal or other (universities, SNSF, users, etc.). To fulfil its coordination role, the national body must have a transparent view of the financial flows for all infrastructures. With a view to preparing decisions on funding at the federal level (four-year ERI Dispatch), the universities and research organisations must define the indicative medium-term financial framework to enable decisions on priority areas of investment and infrastructure closures to be prepared.

2.3 Implementation

In the following section, we present the main challenges regarding the strategic planning and funding of research infrastructures in Switzerland. For each challenge, we show how the model presented above could help in addressing the specific challenge and improving the research infrastructure planning and funding framework. Further clarifications are necessary, and changes in the legal framework in order to clarify the roles in strategic planning and funding, for example, should not be excluded, if they serve the purpose of more clarity and better coordination.

As presented here, the organisational model could be implemented within the current legal framework. With a view to preparing for the 2029-2032 funding period, a mandate could be given by the Confederation to the players in the ERI sector to organise themselves and create the national coordination body. An initial roadmap could be prepared for late 2025 or early 2026 and form the basis for the evaluation of infrastructure proposals (new, major upgrades) by the second half of 2026.[17] Current processes, such as the development of thematic roadmaps or the work of the ORD Strategic Council in various areas, can be integrated into the process.

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[17] We are assuming that the 2029-2032 ERI Dispatch will be published for public consultation in Spring 2027.

3   Challenges and Implementation

The aim of this section is to describe the many complex issues and challenges associated with research infrastructures in Switzerland.

3.1   Strategic Planning: Roadmaps for Research Infrastructures

Increasingly complex and expensive research infrastructure projects require planning and long-term funding models. Research infrastructure roadmaps have been progressively introduced as strategic planning tools for countries to manage their existing infrastructure portfolios and plan future developments.

3.1.1   Roadmaps in European Countries

Most European countries have introduced research infrastructure roadmaps. Despite their diversity in scope, purpose and content, they bring together needs and priorities from different actors in the national research and innovation system and consider scientific excellence and societal aspects. Roadmaps legitimate the process and the decision by all relevant stakeholders.[18] In the European context, national research infrastructure roadmaps are important not only for individual countries' research and innovation systems but also globally, as they support the long-term sustainability of national or international infrastructures that are considered part of the European research infrastructure ecosystem. In 2002 the European Strategy Forum on Research Infrastructures (ESFRI)[19] was established to support a coherent and strategy-led approach to policymaking on research infrastructures in Europe. It is responsible for research infrastructure road mapping at the European level and has introduced new aspects in the road mapping processes to guarantee the long-term sustainability of the European research infrastructure ecosystem and beyond:

– Integration of top-down approaches (elaboration of long-term strategic priorities) and bottom-up approaches (needs of the user communities).
– Landscape analysis (provides context of the most relevant infrastructures, assesses the interconnectedness of infrastructures, the scientific needs, gaps and directions for strategic investments in the future for maintaining excellence in the global context. The analysis is a prerequisite for strategic priority setting at national and international levels).
– Evaluation approaches for the selection of new infrastructures and the quality assessment of existing ones.

ESFRI is also collaborating with the European Research Infrastructure Consortium (ERIC) Forum on the roadmap process and the development of a sustainable infrastructure ecosystem. The ERIC Forum fosters the coordination and collaboration of all the European ERIC infrastructures. ERICs have a specific legal form that facilitates the establishment and operation of infrastructures and is recognised throughout Europe (and recently also in Switzerland). The ERIC Forum also contributes to enhancing knowledge about infrastructures and thrives to become a stakeholder in European policy actions.

It should be noted that Switzerland used to be a member of ESFRI as a country associated with the European Research and Innovation Framework Programmes. However, since 2021 and with the status of a third country, it is no longer invited to take part in the work of the Forum.

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[18] InRoad final report: https://www.inroad.eu/wp-content/uploads/2018/12/InRoad_finalreport.pdf
[19] ESFRI www.esfri.eu

3.1.2   Roadmap in Switzerland

In Switzerland, the Roadmap for Research Infrastructures is launched and coordinated every four years by the State Secretariat for Education, Research and Innovation (SERI). SERI prepares the Roadmap for infrastructures in collaboration with the ETH Board, the Swiss Conference of Rectors of Higher Education Institutions (swissuniversities), the Swiss National Science Foundation (SNSF) and the Swiss Academies of Arts and Sciences.[20] This process is based on a federal strategic vision for the support of research infrastructures, which should align with the individual strategic plans of the higher education institutions, the needs of research (as described for specific domains in thematic roadmaps drawn up by the SCNAT for the Roadmap 2023), and scientific evaluations performed by the SNSF.

However, the process is complex and uncoordinated between the actors and relies on four-year funding periods without considering the prospects for long-term funding of research infrastructures in all aspects (inventory of existing infrastructures, analysis of needs and of institutional strategies, consideration of life cycle, monitoring, international collaboration and alignment) beyond the four years of funding a research infrastructure may have been granted.

In view of the crucial importance of developing research infrastructures, their increasing costs, and the need to ensure their sustainability, the Roadmap process in its current form is not an adequate tool for achieving the effective national prioritisation, selection and long-term funding of research infrastructures. SERI initiated a revision of the roadmap process in May 2023.

3.2   Funding

In Switzerland, according to the law, higher education institutions are in principle responsible for funding research, which includes the core funding of (local) research infrastructures.[21] The Confederation also supports research infrastructures considered of national importance[22] according to Art. 15 RIPA. The SNSF and the Academies complement the funding efforts. Research infrastructures may also be partially supported by other sources, such as foundations, different budget lines from the institutions themselves (including in-kind contributions), or through research projects.

Funding of research infrastructures is planned in the four-year ERI Dispatches along with the individual scientific and political strategies of the actors involved. Due to this fragmentation, financial flows of infrastructure funding are difficult to trace and apprehend. In addition, the four-year planning cycle does not allow for the integration of funding of research infrastructures that have not been considered in the plans, without exceptional measures.

The political structure of Switzerland is also adding complexity to the research infrastructure funding landscape. Whereas the ETH Domain is directly financed by the Confederation and aligns strategically with it, cantonal universities or universities of applied sciences are subject to the strategic and financial responsibility of their cantons, which introduces an additional level of decision-making and dependency. Moreover, institutions are competing for strategic positioning and recognition in funding research infrastructures. As the body responsible for the cantonal universities within the roadmap process, swissuniversities coordinates the identification of new research infrastructures planned by cantonal

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[20] SERI - Swiss Roadmap for Research Infrastructures
[21] See section 2.1
[22] Forschungseinrichtungen von nationaler Bedeutung (in German): Forschungseinrichtungen von nationaler Bedeutung (admin.ch)

universities and the submission of applications for federal funding. However, swissuniversities does not have a dedicated budget for research infrastructures.

The national Roadmap process is seen as an attempt to coordinate the higher education and research institutions strategically and financially around infrastructures of national importance. However, not all research infrastructure actors are involved, and the process does not define responsibilities or unite the actors around clear and common scientific and financial strategies.

The roles in strategically selecting and financing research infrastructures are thus not clearly distributed among the actors and this disparity in both financing and strategic decision-making has favoured neither the strategically well-structured organisation nor the long-term funding of research infrastructures.

3.3 Fragmented Landscape and Legacy

In Switzerland, the research infrastructure landscape is fragmented, a difficulty that is increased by its complex funding structure.

Research infrastructures have been supported by different funders (higher education institutions, the Confederation, the SNSF, academies, etc.), through different selection processes and not in a coordinated way. The result is that the landscape inherited over so many years is heterogeneous and that each infrastructure must be treated in a specific way.

The research infrastructure ecosystem consists of numerous infrastructures that are anchored at one or several institutions and are not necessarily connected with each other. The local and scientific orientation is very strong and research infrastructures are not systematically visible to global user communities in other institutions or in different fields. The absence of an inventory of the Swiss infrastructure landscape illustrates its lack of structure (for example, the lack of a classification of infrastructures covered by the ESFRI definition) and prevents a detailed analysis from being carried out with a view to strategic planning.

Fragmentation of data infrastructures in the Social Sciences and Humanities
Presentation

To respond to the exponential growth of data and the ORD requirements, many data infrastructures have been created in the SSH: FORS, in Lausanne, for the social sciences, which hosts a repository, performs enquiries and manages longitudinal studies, DaSCH, in Basel, which provides expertise in research data management for the humanities, LiRI, in Zurich, which offers technological and data services in linguistics, and many other local initiatives, such as OLOS for data management.

Issue related to fragmentation

These infrastructures have been created to respond to specific needs of local communities. Their visibility to global users is thus not extensive and the local use and development of the infrastructures leads to overlaps and redundancies. Moreover, a coherent technological and strategic development is impaired, which allows neither the economy of means nor of scale. Furthermore, the financing mechanisms of these infrastructures are different (institutions, programmes, SNSF, etc.), which complicates their coordination and long-term funding.

ESFRI landscape analysis

Presentation

The ESFRI landscape analysis provides an inventory of the most relevant research infrastructures available to researchers in Europe, captures the requirements for and gaps in research infrastructures, and delineates strategic investments for the future development of the European research area. New projects can thus be proposed to fill the gaps in the different disciplines. In doing this, ESFRI also highlights the relevant connections between the research infrastructures and shows new linkage needs. This analysis is seen as the prerequisite for strategic priority setting at the European and national levels. It also shows the relevance of investing in infrastructures for environmental, economic and societal issues and is a tool to promote research infrastructures and their services and to reach out to new international partners.

Isse related to the lack of structure

Switzerland lacks an inventory of national research infrastructures and international research infrastructures relevant to Swiss research. It also lacks any initiative that would allow analysis of the scientific, economic or societal impact of infrastructures as well as the gaps or emerging needs. In the absence of such tools, delineating strategic and economic national visions for infrastructures is difficult and impairs the development of a coordinated, sustainable and state-of-the-art national infrastructure ecosystem.

Recommendations

– **Structured overview of the existing infrastructures:** The decisions regarding the funding of new or existing infrastructures needs to be based on the knowledge of the national infrastructure landscape to avoid duplications or the creation of similar infrastructures. The proposed inventory with information on the purpose, governance, services, and links with international infrastructures is necessary to orientate the decision towards the creation, continuation, fusion or termination of infrastructures.

– **Strategic analysis on research infrastructures**: Decisions for funding may as well be supported by a landscape analysis that highlights the current context, needs, gaps and directions for future investments, and takes into consideration the international developments relevant to the national infrastructure ecosystem. This analysis can also provide information on the socio-economic aspects and potential impacts of infrastructures. The two tools – the inventory and the landscape analysis – would provide a strategic basis for sustainable and competitive funding of coordinated infrastructures.

3.4   Heterogeneity and Complexity

The Swiss research infrastructure landscape consists of a large variety of objects of different sizes, outreach, purposes, structures, developmental phases and funding mechanisms. Whereas some have been built around cost-intensive equipment at a single site (e.g. microscopy facilities, accelerators, telescope or supercomputers), others consist of networks and enable the sharing of data or are coordinated multi-centric resources (e.g. repositories, measurement instruments, data infrastructures and services).

The existence of infrastructures also generated the creation of research programmes around the use of the infrastructure and prompted thematic communities to organise their own financing to access the

infrastructure for its data (e.g. FLARE[23], see box). On the other hand, scientific programmes such as the structuring of NCCRs in Switzerland or, on a larger scale, the European Joint Programming Initiatives or the Future and Emerging Technologies Flagships, may prompt the establishment of research infrastructures around thematic priorities. This results in strong and long dependencies that are difficult to stop or modify according to topical researchers' needs. Such programmes are also of limited duration and further funding of the research infrastructures generated may not be secured once the programmes are terminated, irrespective of the scientific quality and importance of the infrastructure.

This heterogeneity makes the comparison, selection, prioritisation and sustainable development of research infrastructures extremely challenging and it is difficult to establish a coherent and coordinated RI ecosystem, particularly from the perspective of long-term funding.

FLARE

Presentation

The Funding LArge international REsearch projects (FLARE) programme aims at optimising the use of international research infrastructures and organisations by Swiss researchers in the field of particle physics, ground-based and underground-based astrophysics and astroparticle physics (space missions are excluded). The programme is funded by SERI. One part of the budget is devoted to the Swiss participation in the LHC activities, and it is not subject to evaluation. The rest of the projects are evaluated by an international panel and only costs for development, construction, maintenance and operation of internationally recognised experiments in the domains defined by the FLARE call are granted. Costs for personnel (postdoctoral fellows, technicians) are not eligible and are often funded through the SNSF Project Funding scheme.

The applicants are researchers from the CHIPP (Swiss Institute of Particle Physics) and CHAPS (College of Helvetic Astronomy ProfessorS) communities. These two communities are also invited to assign to each experiment a long-term funding priority. This priority and the long-term commitment to the overall experiment of the institutions employing the applicants are included as two of the five FLARE evaluation criteria.

Isse related to complexity and dependencies

The success rate for regular SNSF project funding applications in the FLARE disciplines has decreased over time and it is now in line with the average funding rate for SNSF projects. There is thus the risk that fundamental research, such as that carried out at CERN, will not be adequately supported, especially over the long term because of the dependency on SNSF grants.

To be competitive in the long term, MoU agreements should be signed and implemented. However, four-year funding means there is a high risk involved in signing such agreements, since the funding is not guaranteed.

The experiments will need to have posts that fall between the scientific and technical activities of a project. Funding these posts is challenging both in FLARE and in Project Funding schemes.

NCCR enhanced infrastructure: LiRI

Presentation

The linguistic research infrastructure LiRI is a technology platform for linguistic researchers[24]. It is closely related to NCCR Evolving Language which aims to explore language through interdisciplinary

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[23] FLARE 2023-2024: Call for proposals 2022 (snf.ch)
[24] LiRI: https://www.liri.uzh.ch

approaches. LiRI was set up as part of the National Roadmap for Research Infrastructures and is integrating the data from the NCCR to promote synergies and for mutual scientific benefit.

Issue related to dependencies

The synergistic efforts of LiRI and the NCCR boost the development of the platform and increase its visibility at the national level. However, the thematic priorities of LiRI and the NCCR may not respond to the evolving needs of the larger scientific community and integrating them into the collaboration may be difficult at the scientific, technological and financial level. In addition, funding of the NCCR is limited in time, and data flows and synergistic endeavours may be compromised at the end of the programme, should no continuation of funding be guaranteed.

Recommendation

– **Dependencies between research infrastructures and research:** The funding of infrastructure and associated services must be clearly separated from the funding of research that uses infrastructure services. Research activities may be justified for the development phase of an infrastructure, but in that case they are covered by the infrastructure's own funding and must be geared towards the purpose of the infrastructure itself. Provision must be made for the medium to long term to ensure financial transparency. Specific budgets are set aside for very long-term commitments (large-scale experiments, space missions, etc.).

3.4 International Integration

International integration of Swiss research infrastructures is triggered by different processes. It may occur through state agreements, especially for large organisations, such as CERN in particle physics or the Square Kilometre Array[25] (SKA) in astronomy. With such initiatives, political considerations also drive the decision to participate, and participation binds funds for the long term. It may be part of the national Roadmap, which considers Switzerland's participation in international research infrastructures every four years. It may also occur on the initiative of research communities that crucially depend on international infrastructures, but again without sustainable financing forms (e.g. IODP and ICDP in the earth sciences).

ERIC, the European Research Infrastructure Consortium,[26] is a legal and organisational framework established by the European Union to facilitate the establishment and operation of pan-European research infrastructures. It was created to address challenges related to the management, operation and financing of large-scale research infrastructures that involve multiple countries and stakeholders. The ERIC framework provides a simplified legal structure for international cooperation, allowing participating countries to pool resources, share expertise, and jointly manage the research infrastructure. Swiss full membership in ERIC infrastructures has been recently approved by the Confederation, and Switzerland participates at present in six ERIC infrastructures.[27] Participation in other ERICs is evaluated. Membership fees are paid by SEFRI. However, such infrastructures rely on a network of national infrastructures (national nodes), for which financing is not secured as it relies on institutions, or other institutions such as the SNSF, whose budgets are tied to multi-year plans. It should be noted that applying the ERIC legal framework is complex and relies on the political decisions of the member states. The different strategic focuses may change and impede the maintenance and development of ERIC. It is crucial to carefully analyse the legal form of international infrastructures before any decision on participation. Recent developments show that other legal forms of international infrastructures are more

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[25] Square Kilometre Array Observatory: https://www.skao.int/
[26] European Research Infrastructure Consortium (ERIC): https://www.eric-forum.eu/
[27] Swiss participation in ERIC infrastructures: European research infrastructure networks (admin.ch), not counting the Swiss participation in the European Spallation Source, which is a facility governed by an ERIC-based legal form.

compatible with the direct responsibility of institutions which perform research and would be preferred to ERIC: one example is the Belgian *Associations Internationales Sans But Lucratif* (AISBL). ERIC requires the participation of the states in the consortium. As funders of the national nodes, they decide on the development and sustainability of the infrastructure. The AISBL legal form nevertheless allows the institutions performing research to participate without national delegation in the infrastructures and to take direct responsibility.

As an integral part of research, participation in international infrastructures is essential to achieve scientific excellence, maintain state-of-the-art scientific know-how and network scientists. This can also translate into the economy of means, as infrastructures can benefit from one another's advances or experiences and reach larger scientific communities. This however leads to strong commitments to hosting and funding them in the long term and solving additional legal issues. In addition, participation in international, especially European, infrastructures has become more sensitive due to Switzerland's political exclusion from Horizon Europe. Through research infrastructures, the Swiss scientific community remains connected with international researchers and state-of-the-art science.

A better coordination of the decision and funding of the participation in such infrastructures is needed. Whereas the needs of the communities and the benefits for Switzerland as a centre of research are assessed when deciding whether or not to participate, the responsibility of the funders is not clear, and nor is their commitment over time.

Financing of ERIC Swiss nodes

Presentation

Switzerland is a member of six ERICs and is considering participating in others. Participation in ERIC occurs through local infrastructures, the national nodes, that contribute to the ERIC network. The national nodes may consist of established infrastructures (FORS for CESSDA-ERIC and the Swiss Biobanking Platform for BBMRI-ERIC). At present, the funding of the national nodes relies on individual institutions and their multi-year plans. By entering the ERIC networks, infrastructures need to comply with the ERIC requirements and participate in the development of the network. This leads to increased costs for the nodes.

Issue related to participation in international infrastructures networks

Funding for the six national nodes is not secured in the long term, which may compromise participation in the ERICs and have an impact on the research communities involved. Moreover, the institutional budgets are delineated in the multi-year plans and distributed for defined tasks. This does not allow financial flexibility for funding national nodes of new ERICs that Switzerland deems important to join. This is presently the case for the national node of GGP-ERIC, which Switzerland will join very soon.

IODP/ ICDP

Presentation

The International Ocean Discovery Program (IOCD) and the International Continental Scientific Drilling Program (ICDP) explore Earth history and dynamics using targeted drilling of marine and continental soil. Switzerland participates in the programme by paying membership fees to access the infrastructures (drilling platforms and data), and participates in committees and workshops. At present, the SNSF pays the membership fees.

Issue related to participation in international programmes

Whereas the interest shown by different communities in this field is increasing (geology but also tectonics, volcanology, biogeochemistry, etc.), no institution has so far committed to participating in the programme. To avoid compromising the international collaboration and the sharing of essential samples and data, the SNSF has agreed to pay the membership fees for the present. This is however an exception, as the SNSF has no instrument for participation in international programmes that would be accessible to all disciplines, so it could stop making these payments. Long-term support is thus not guaranteed.

Recommendation

– **Participation in international infrastructures:** Collaborating and participating in international infrastructures is crucial to Swiss research. It may take different forms and require different funding for different periods of time. Thanks to the inventory of infrastructures and their relations with international counterparts, and the future-oriented perspective of the strategic landscape analysis, decisions on funding may also be more efficiently foreseen, prepared for and coordinated using the long-term roadmap. This would give the funders more flexibility to design their strategic plans and related budgets, and distribute the responsibilities and resources better.

3.5 Digitalisation and Open Research Data

Data and Open Research Data (ORD) principles have become essential aspects of research infrastructures as they generate, store or connect data, and make it widely available. In addition, and to respond to the needs of academia with regard to Open Research Data, new types of infrastructures relating to the implementation of the FAIR Principles[28] raised and opened up new avenues for research and research on data. For example, interdisciplinary approaches based on the nature of the data are emerging (e.g. work with sensitive data both in biomedical and social sciences). Moreover, they raise increasing expectations from the economy and society. The rapid developments seen in artificial intelligence in the field of data science also create new opportunities and challenges that need to be considered in research infrastructures.

National ORD Strategy and the ORD Strategy Council

Published in 2021 and jointly developed by swissuniversities, the ETH Board, the SNSF and the Swiss Academies for Arts and Sciences on a mandate from SERI, the Swiss National Open Research Data Strategy sets a framework for the common development of practices on sharing research data in Switzerland. It targets publicly financed research data and defines several aims for the development of a common approach towards ORD solutions for institutions and research communities as well as for the strategic development of ORD infrastructure and services. The ORD Strategy Council, composed of high-level representatives of the ORD actors, is mandated by SERI to develop a shared vision of the ORD landscape in Switzerland in line with the national ORD strategy and to ensure the coherence and interoperability of all infrastructure and services in terms of data. However, the implementation of the ORD strategy is complex as many initiatives have been taken on an individual basis, either by institutions or on a mandate from SERI, and these need to be coordinated for more clarity and transparency towards the users and for sustainable financing (e.g. in the life sciences, see box).

To serve the scientific community at large and take advantage of the synergies and possibilities data and artificial intelligence offer, research infrastructures need to align with the national ORD strategy, coordinate with each other and share experience and know-how.

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[28] Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data 3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

In addition, with the growth and increasing interoperability of data, new infrastructures based on data and applying methods of artificial intelligence are emerging, creating new research opportunities but also new needs to be met. Such infrastructures are different in their nature from infrastructures centred on facilities or measuring instruments, as they need little start-up financing but grow gradually and incur the risk of not involving as many users as foreseen. As new and necessary infrastructures, their long-term funding has also to be considered and integrated into the national Roadmap process. Being established for the infrastructures based on facilities or measuring instruments, the Roadmap does not offer adequate conditions for the prioritisation and planning of data infrastructures.

Due to its pioneer role in ORD and in close collaboration with the ORD Strategy Council, the SNSF has shown an interest in funding and developing data infrastructures and services (DIS) that support the implementation of FAIR principles in line with the national ORD strategy, starting with the humanities (DaSCH) and the social sciences (FORS) and the transformation of the transplant and HIV cohorts into data infrastructures.

Data infrastructures in the Life Sciences

Presentation

Interoperability and sharing of the exponential increase in data has become crucial in the Life Sciences since it enables yet unmet health issues to be tackled and promotes the development of personalised health. However, accessing and exchanging clinical or human biobanking data is challenging compared with other data: i) it is sensitive data subject to constraining legal and ethical requirements, ii) it is the property of the hospitals where it is collected according to local standards and is thus not interoperable, not findable and has restricted access.

Isse related to Open Research Data

Numerous initiatives implementing aspects of the ORD strategy to biological and clinical data have emerged: initiatives funded by institutions (e.g. HPRT at the Federal Institutes of Technology, biodata resources of SIB, university hospitals), by SERI (e.g. Swiss Personalised Health Network SPHN), by the SNSF (e.g. Swiss Biobanking Platform) and by the SNSF on a mandate from SERI (e.g. Swiss HIV and Swiss Transplant Cohort Studies) and many more. The implementation of the national ORD strategy is thus not centrally coordinated, and it is difficult to assess the current level of interoperability of infrastructures, whether all are needed and visible to users, or which ones are redundant or less used and could be merged or terminated. Moreover, funding for all these infrastructures is not secured over the long term. To coordinate this ecosystem and achieve long-term financing as well as transparency towards the users, the ORD Strategy Council has decided to develop models for strategic implementation of the ORD national strategy in the life sciences for the attention of SERI. A similar challenge remains to be tackled in other disciplines, for example in the social sciences and humanities.

Recommendations

– **Additional efforts for data and Open Science in infrastructures:** Thanks to its exponential growth, managing data has become complex. Infrastructures must align with the national ORD strategy if they are to make their data interoperable and accessible to the users. Working with data has gained in importance, scientifically and for societal and economic purposes, but requires specialised and additional manpower. This type of work needs to be considered in the evaluation and funding of infrastructures. Moreover, the national ORD strategy implementation should be coordinated between the different infrastructures, and this may be a role for the ORD Strategy Council, as it covers the coordination of data infrastructures.

– **Specific criteria for data infrastructures and related services**: Many infrastructures based on data have emerged. Their purpose and structure are different from those of

infrastructures built around instruments, and the criteria to evaluate them have not yet been developed. Whereas they require less initial funding, their needs may increase rapidly with time. Appropriate evaluation criteria considering their mission and nature must be defined to integrate them into the infrastructure ecosystem and secure their long-term funding. In addition, the data infrastructures are not coordinated. The proposed inventory should investigate the redundancies and synergies between data infrastructures and organise them: purpose, communities, data and developments. This would lead to more coordinated efforts and optimise the costs. The ORD Strategy Council has launched such an approach in the Life Sciences and in Social Sciences and Humanities.

3.6   Interdisciplinarity, Trans-disciplinarity and Societal Challenges

Interdisciplinarity has rapidly developed in many scientific domains in response to contemporary challenges and technological or disciplinary evolutions that opened new opportunities. By bringing open access to technologies, data, training and scientific services, research infrastructures must grow from a disciplinary perspective to a broader one and may serve different disciplines. This is particularly true for data infrastructures whose data and services may encompass several disciplines or even disciplinary fields. Interdisciplinarity thus needs to be considered when developing and selecting research infrastructures as it mirrors the latest scientific developments and needs.

Research infrastructures attract interest in society at large, as shown for example during the Covid-19 pandemic with the use and re-use of data. However, many infrastructures are not able to respond to these challenges. Funding is insufficient to integrate new tasks as they may require additional human resources and new technological developments. Institutions have difficulties making additional funds available as their budgets are tied to multi-year plans enshrined in the structure of their funding framework. In addition, infrastructures of public interest outside the ERI domain and supported by public funds may be launched to respond to urgent or important societal questions (e.g. patient databases for disease surveillance, databases in response to pandemics, or environmental measurements). Funding is usually provided for the creation of new infrastructure and immediate results, but it is difficult to define a long-term strategy for its development and financing (see box). In this case again, further funding outside the ERI Dispatch, despite the scientific and societal aspects, is the stumbling block for such infrastructures.

Industry has shown interest in collaborating with academic research infrastructures. Collaboration between publicly funded academia and the private sector is complex, however, and plays a crucial role in fostering scientific advances and innovation. At the European level, ESFRI analysed the cooperation between research infrastructures and industry and showed that intensive cooperation is already being developed, whereas the form of cooperation varies individually and needs further development[29]. Research infrastructures have significant innovation potential and cooperation with industry should be considered, and the legal, economic and scientific aspects clarified, for potential implementation and mutual benefit.

The Swiss Pathogen Surveillance Platform

Presentation

Established within the framework of National Research Programme 72 on Antibiotic Resistance, the Swiss Pathogen Surveillance Platform (SPSP) is collecting and sharing whole genome sequences and related data on bacterial, multi-drug resistant bacterial and viral pathogens. It serves both national

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[29] ESFRI: « Cooperation of ESFRI research infrastructures (Landmarks) with industry, report 2022): https://zenodo.org/record/8205249

pathogen surveillance (enabling detailed transmission and outbreak surveillance in near real-time, in the interest of the Federal Office for Public Health (FOPH) and research (data repository accessible to researchers). In addition, the aims of the SPSP are aligned with international efforts such as Nextstrain that use the potential of pathogen genome data to follow evolving pathogen populations. [30]

Issue related to trans-disciplinarity and societal challenges

It has been funded so far through different sources (NRP 72, individual research grants, FOPH, Swiss Institute for Bioinformatics). However, NRP 72 is ending, and this involves the termination of funding, which was tied to the duration of the programme. The further support of SPSP was part of a project submitted to Roadmap 2023 for institutional support, but not retained. The future of the platform is thus in question, although its scientific and clinical relevance is undeniable as well as its value for epidemiology and disease prevention. In this case, the interruption of the platform would have important consequences for public health and research. Moreover, public money was invested in establishing the platform, which brings with it a responsibility to attain the expected goals and serve the community. In the absence of any common decision process for the funding of research infrastructures outside the Roadmap process and without a committed budget to allocate, the question of how funding responsibility is divided between the ERI actors, including the federal offices in this case, is raised.

Recommendations

– **Extension to other disciplines or purposes:** To reflect the increasing interdisciplinarity of research, infrastructures must open up to other disciplines and diversify their activities to respond to the needs of different scientific communities and society at large in relation to their instruments or data. The proposed inventory, with its structure based on the different types of resources, will allow for the mapping of existing disciplinary infrastructures and their set of services, and, together with the landscape analysis, will show the potential for building interdisciplinary collaborations and achieving economy of means and resources. In addition, the proposed analysis of needs, from researchers, the government or society, will also guide the infrastructures in integrating suitable interdisciplinary approaches.

– **Coordination with publicly funded infrastructures outside of research**: Starting funds for infrastructures may be invested in by federal departments for responding to societal issues deemed important or urgent. However, these infrastructures may develop independently and develop overlaps or complementarities with other research infrastructures, and their funding is not secure in the long term. These infrastructures should be considered in the proposed inventory, or the project for their creation should be discussed with the national body to investigate possible integration in existing infrastructures or as new infrastructure in the long-term roadmap.

3.7 Professionalisation

Research infrastructures are complex organisations: they deliver highly specialised scientific and technological services, interact with different stakeholders, and need to ensure their sustainable funding. They must guarantee scientific excellence, manage huge amounts of data, and adapt to remain competitive and be able to respond to new needs.

To respond to these challenging expectations, the management and running of infrastructures have transformed into professional activities and need the specialised skills and experience of highly qualified personnel. In this respect, specific competencies for operating infrastructures must be developed

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[30] Nextstrain: https://nextstrain.org/

and recognised as new professions: at the managerial level (managers of research infrastructures), the data management level (data stewards, data management policy makers, internal training, and development, etc.) and for operating highly complex facilities (technicians, scientists). Such competences are to be found in academia, or can be trained within the infrastructures, and may provide new career opportunities beyond research (including training, development of skills and career prospects).

Being competitive means also monitoring the infrastructures' performance. Several methods have been defined to track the progress made by infrastructures towards their objectives. ESFRI developed an approach for monitoring the progress of infrastructures and proposed a list of possible key performance indicators (KPIs), which are applied to ESFRI infrastructure monitoring.[31] However, given the diversity of types and aims of infrastructures, these indicators need to be adapted to the specific character and context of the individual infrastructures in order to be effective. The use of performance indicators also needs to evolve with the development of new infrastructures and to be refined as experience is gained in their application.

Recommendations

– **Recognition of the professionalisation of research infrastructures:** To remain competitive in the long term, which involves responding to the needs of the researchers and stakeholders, operating sophisticated technologies, managing the increasing data and the new methodologies around data, and ensuring national and international integration, infrastructures need a solid and highly specialised management. Such competencies must develop into new professions to ensure the sustainable operation and management of infrastructures. Training can take place in higher education but also directly in the infrastructures. These professions, such as executive managers, data stewards, IT developers, engineers, technicians, etc. should be recognised and validated in academia as a means of career development. The national body, including SERI, could coordinate the definition of the professions and validate their development in the infrastructure ecosystem. On the other hand, certain infrastructures have been created by user communities and do not yet benefit from professional management. The latter should be included in their future development to make them effective and competitive.

– **Systematic monitoring of performance**: Progress towards the goals of an infrastructure needs to be monitored to maintain the level of excellence and ensure the relevance of the infrastructure. Allowance would also be made for agreeing deviations from or modifications to the goals if needed. As infrastructures are very diverse in their purposes and structures, indicators for monitoring should be established for each type of infrastructure service. The proposed inventory would help the national body to define performance indicators for the different aspects of research infrastructures and ensure monitoring. The results of the monitoring will enter the proposed inventory and landscape analysis and be integrated into the long-term Roadmap.

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[31] ESFRI Monitoring of Research Infrastructure Performance: https://www.esfri.eu/sites/default/files/ESFRI_WG_Monitoring_Report.pdf

4   Conclusion

In this paper, the SNSF sets out its own analysis of the situation in the field of research infrastructures and proposes a possible solution to the problems that have been identified in the past. The aim of this document is to stimulate a constructive dialogue that can lead to a new Roadmap process for research infrastructures that improves the agility and competitiveness of research and innovation in Switzerland, in recognition of the major challenges we face and will have to face in the years ahead.

5 Glossary

BBMRI	Biobanking and Biomolecular Resources Research Infrastructure
CERN	Conseil Européen pour la Recherche Nucléaire
CESSDA	Consortium of European Social Science Data Archives
DaSCH	Data and Service Centre for the Humanities
Dodis	Swiss Diplomatic Documents
ECORD	European Consortium for Ocean Research Drilling
ERI	Education, Research and Innovation
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ESO	European Southern Observatory
FLARE	Funding LArge international REsearch
FORS	Swiss Centre of Expertise in the Social Sciences
GGP	Generations and Gender Programme
HLS	Historisches Lexikon der Schweiz
ICDP	International Continental Scientific Drilling Program
ICOS	Integrated Carbon Observation System
IODP	International Ocean Discovery Program
ILL	Institut Laue-Langevin
LiRI	Linguistic Research Infrastructure
MARVIS	Multidisciplinary Advanced Research Ventures in Space
NCCR	National Centre of Competence in Research
OECD	Organisation for Economic Co-operation and Development
OLOS	Integrated data management solution
ORD	Open Research Data
PHRT	Personalised Health and Related Technologies
RIPA	Research and Innovation Promotion Act
RIPO	Ordinance to the Federal Act on the Promotion of Research and Innovation
SCNAT	Swiss Academy of Sciences
SCTO	Swiss Clinical Trial Organisation
SERI	State Secretariat for Education, Research and Innovation
SHCS	Swiss HIV Cohort Study

SKA	Square Kilometre Array
SKAO	Square Kilometre Array Observatory
SPSP	Swiss Pathogen Surveillance Platform
SSH	Social Sciences and Humanities
STCS	Swiss Transplant Cohort Study
SwissCollNet	Swiss Natural History Collections Network