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Schweizer Roadmap für Forschungsinfrastrukturen im Hinblick auf die BFI-Botschaft 2021–2024

(Roadmap Forschungsinfrastrukturen 2019)

Vom Bundesrat als Grundlagenpapier für die BFI-Botschaft 2021–2024 am 17. April 2019 zur Kenntnis genommen

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Management Summary

Die Roadmap Forschungsinfrastrukturen 2019 ist ein strategisches Planungsinstrument. Damit werden zum einen die neu geplanten nationalen Forschungsinfrastrukturen sowie die Beteiligung der Schweiz an internationalen Forschungsinfrastrukturen erfasst. Zum andern wird mit der aktuell vorliegenden Roadmap der Umsetzungsstand der in der vorangehenden Roadmap geplanten Forschungsinfrastrukturen aktualisiert. Sie ist Teil des Erarbeitungsprozesses der BFI-Botschaft 2021−2024 sowie der EU-Botschaft für die kommende Beitragsperiode. Ausserdem gibt sie mittelfristig Hinweise für den weiteren Finanzierungsbedarf im nationalen und internationalen Bereich. Die Roadmap enthält jedoch weder Finanzierungsbeschlüsse noch Entscheide zur Verteilung allfälliger Bundesmittel.

Forschung und Innovation sind Voraussetzungen für wirtschaftlichen und gesellschaftlichen Fortschritt. Die Akteure des Forschungsbereichs sind deshalb in allen Fachbereichen auf exzellente Forschungsinfrastrukturen als wichtige Grundlage ihrer Tätigkeiten angewiesen. Dazu zählen etwa Grossforschungsanlagen (z.B. Teilchenbeschleuniger), e-Infrastrukturen (z. B. Hochleistungsrechner) oder Datenbanken. Betroffen sind alle Forschungsbereiche, von der Physik über die Biologie und Informatik bis hin zu den Geistes- und Sozialwissenschaften. Die meisten Infrastrukturen decken mehrere Forschungsbereiche gleichzeitig ab. Aufgrund immer multidisziplinärer ausgerichteter Forschungsprojekte wie auch angesichts der technologischen Entwicklungen wächst die Bedeutung solcher kostenintensiver, aber für mehrere Forschungsbereiche zugänglicher Forschungsinfrastrukturen (FIS). Ebenso nimmt der Bedarf an neuen FIS zu. Dies verlangt eine mittel- und langfristige Finanzplanung durch die finanzierenden Stellen. Dabei muss nicht nur zwischen der Einrichtung neuer nationaler FIS und der möglichen Beteiligung an internationalen FIS sorgfältig abgewogen werden, sondern auch zwischen der Einrichtung neuer FIS und der Ausschliessung, der Weiterführung beziehungsweise Weiterentwicklung bestehender FIS.

Die vorliegende Roadmap Forschungsinfrastrukturen 2019 liefert im Hinblick auf die Botschaft zur Förderung von Bildung, Forschung und Innovation in den Jahren 2021−2024 (BFI-Botschaft) einen generellen Überblick über neu geplante FIS. Zudem enthält sie ein Update der FIS, die im Hinblick auf die BFI-Botschaft 2017−2020 in die Roadmap 2015 aufgenommen wurden und in Zukunft weiterfinanziert werden sollen. Ein umfassenderes Inventar, das auch zahlreiche vor 2017−2020 betriebene Infrastrukturen umfasst, ist im Bericht «Forschungsinfrastrukturen 2015» zu finden, der vom Staatssekretariat für Bildung, Forschung und Innovation (SBFI) veröffentlicht wurde.

Das SBFI hat gemäss Forschungs- und Innovationsförderungsgesetz (FIFG) den Prozess zur Erstellung der Roadmap koordiniert. Die von Forschenden in der Schweiz vorgeschlagenen FIS-Vorhaben wurden anhand der Einschlusskriterien und anderer institutionsspezifischer Vorgaben (z.B. interne Strategien) von den zuständigen Stellen (ETH-Rat und swissuniversities) geprüft. Nach dieser ersten Selektion (Phase 1) folgten zwei weitere Evaluationsphasen. Auf der zweiten Evaluationsstufe (Phase 2) beurteilte der Schweizerische Nationalfonds (SNF) die eingereichten Vorhaben nach wissenschaftlichen Kriterien und priorisierte sie in drei Kategorien (A, B, C). Auf der dritten Evaluationsstufe (Phase 3) wurden die Vorhaben anschliessend von den zuständigen Stellen (ETH-Rat und swissuniversities) anhand von Kriterien betreffend Planung, Governance und Management sowie im Hinblick auf ihre finanzielle Umsetzung und Unterstützung durch die jeweiligen Institutionen übergeprüft. Die zuständigen Stellen hatten insgesamt 15 neue Vorhaben zur Umsetzung vorgeschlagen. Davon waren acht völlig neu und bei sieben handelte es sich um substanzielle Upgrades von bestehenden FIS. Sieben der 15 vom SNF geprüften Vorhaben (darunter vier Upgrades) wurde eine hohe wissenschaftliche Bedeutung zugesprochen (Priorität A). In der vorliegenden Roadmap sind letztlich nur diese Vorhaben enthalten, die die Prüfung in Phase 3 erfolgreich bestanden haben.

Im Rahmen dieser Roadmap wurde der SNF vom SBFI zudem beauftragt, zur Relevanz von 15 internationalen Infrastrukturen Stellung zu nehmen. Das Mandat bestand darin, die Bedeutung der Schweizer Beteiligung an diesen internationalen Infrastrukturen und Organisationen zu prüfen. Der SNF beurteilte zwölf internationale Forschungsinfrastrukturen als prioritär («hohe Priorität»).

1. Einleitung

1.1. Inhalt des Roadmap-Berichts

Das Staatssekretariat für Bildung, Forschung und Innovation (SBFI) ist verantwortlich für die Erstellung der vorliegenden Roadmap für Forschungsinfrastrukturen 2019 («Roadmap 2019») und für den mit seinen Partnern, namentlich dem ETH-Rat, der Rektorenkonferenz der schweizerischen Hochschulen (swissuniversities) und dem Schweizerischen Nationalfonds (SNF), durchgeführten Prozess.

Kapitel 2 umfasst einen Rückblick auf die laufende BFI-Periode und die nationalen und internationalen Verpflichtungen, die sich aus der Roadmap 2015 ergaben. Der Umsetzungsstand der nationalen Vorhaben ist in Anhang A2 zu finden. In Kapitel 3 wird das Verfahren der Roadmap 2019 dargelegt. In Kapitel 4 sind die Ergebnisse des Erhebungsverfahrens (Phase 1) und die Beurteilung durch den SNF zu finden. In Kapitel 4 findet sich auch eine allgemeine Übersicht der FIS, die vom SNF zur Umsetzung vorgeschlagen werden (Phase 2).

Kapitel 5 umfasst eine vertiefte Beschreibung der vom SNF empfohlenen FIS, ihre Beurteilung durch die zuständigen Stellen sowie die Endergebnisse (Phase 3). Kapitel 6 stellt die weiteren Massnahmen zur Förderung der FIS vor, die von den Förderorganen (SNF, Akademien der Wissenschaften Schweiz) unterstützt werden. In Kapitel 7 werden schliesslich die Vorhaben erläutert, die im Rahmen der europäischen ESFRI-Roadmap[1] und der internationalen Forschungsorganisationen geplant sind.

In Anhang A1 sind die neu eingereichten nationalen FIS von hoher wissenschaftlicher Bedeutung aufgeführt. In Anhang B1 finden sich die internationalen Forschungsinfrastrukturen, für die eine Schweizer Beteiligung zu prüfen ist. Anhang B2 führt die internationalen Forschungsorganisationen auf, an denen sich die Schweiz beteiligt oder beabsichtigt, zu beteiligen.

1.2. Zielsetzung der Roadmap

Forschungsinfrastrukturen sind in vielen Fachgebieten eine zentrale Voraussetzung, um zu neuen wissenschaftlichen Erkenntnissen zu gelangen, Fachgebiete weiterzuentwickeln oder neue Forschungsgebiete zu erschliessen. Der Bedarf an solchen Forschungsinfrastrukturen ist in den letzten Jahren weitergewachsen und damit verbunden auch der Finanzbedarf. Zudem erfordern grosse Forschungsinfrastrukturen von nationaler oder internationaler Bedeutung eine mittel- und langfristige Koordination auf nationaler und internationaler Ebene. Auch verlangen sie eine umsichtige Planung, um einerseits die begrenzten finanziellen Mittel möglichst effizient und effektiv einsetzen zu können, und um andererseits, einen geregelten und gezielten Zugang für die Akteure des Forschungs- und Innovationsbereichs zu gewährleisten.

Geht es um eine Beteiligung der Schweiz an einer internationalen Forschungsorganisation auf der Basis eines völkerrechtlichen Vertrags, kommen zudem rechtliche und aussenpolitische Aspekte hinzu, die den Planungs- und Koordinationsbedarf erhöhen.

Vor diesem Hintergrund dient die vorliegende Schweizer Roadmap Forschungsinfrastrukturen 2019 («Roadmap 2019») als Planungsinstrument und als eine der Grundlagen für die Erarbeitung der entsprechenden Finanzbeschlüsse des Bundes im Rahmen der BFI-Botschaft 2021–2024 sowie der EU-Botschaft. Die Roadmap ist weder eine Erhebung für Sonderfinanzierungen noch ein Verfahren mit Finanzierungsbeschlüssen.

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

Die Finanzentscheide zur Umsetzung einzelner Forschungsinfrastrukturvorhaben erfolgen, soweit sie in der Zuständigkeit des Bundes liegen[2], im Rahmen der BFI-Botschaft 2021–2024:

- aufgrund der strategischen Planung der Hochschulen und der Mehrjahresprogramme der zuständigen Förder- und Trägerinstitutionen;
- aufgrund der Ergebnisse aus dem Evaluationsverfahren dieser Roadmap;
- aufgrund der Überprüfung der effektiven Notwendigkeit einer spezifischen Bundesunterstützung gemäss Subventionsgesetz (SR 616.1);
- auf der Grundlage des Finanzrahmens der mehrjährigen Finanzbeschlüsse (BFI und EU), wie er vom Bundesrat für die Periode 2021-2024 festgelegt wurde.

[2] Zur Zuständigkeit des Bundes s. Kap. 5.1.

2. Rückblick auf die laufende BFI-Periode 2017–2020

2.1. Einleitung

Die vorliegende Roadmap 2019 ist der dritte Bericht dieser Art, den das SBFI veröffentlicht. Die beiden vorangehenden Berichte wurden 2011 und 2015 publiziert. Die erste Roadmap diente als Grundlage für das Kapitel «Forschungsinfrastrukturen» der BFI-Botschaft 2013–2016. In erster Linie war sie aber eine Antwort auf die europäische ESFRI-Roadmap 2008, mit der die europäischen Länder eingeladen wurden, nationale Roadmaps zu erstellen, um die Plan- und Finanzierbarkeit grosser, international koordinierter Forschungsinfrastrukturvorhaben zu verbessern.

2.2. BFI-Periode 2017–2020: Roadmap Forschungsinfrastrukturen 2015 und ihre Umsetzung

Die Schweizer Roadmap Forschungsinfrastrukturen 2015 (Roadmap 2015) war einerseits auf Infrastrukturen mit gesamtschweizerischem Auftrag und andererseits auf internationale Infrastrukturen und eine mögliche Beteiligung der Schweiz an diesen ausgerichtet.

Der Bundesrat hat den Schlussbericht zur Roadmap 2015 am 24. Juni 2015 zur Kenntnis genommen. Aufgrund der Prüfung der effektiven Notwendigkeit einer spezifischen Bundesunterstützung und der für die einzelnen Förderkredite zur Verfügung stehenden Finanzmittel beantragte der Bundesrat dem Parlament im Rahmen der BFI-Botschaft 2017–2020, die folgenden bestehenden FIS weiterhin zu unterstützen:

a) Nationale FIS

Vom ETH-Bereich erwartet der Bundesrat, dass er grosse Forschungsinfrastrukturen von gesamtschweizerischer und internationaler Bedeutung betreibt, sie weiterentwickelt und den Forschenden zur Verfügung stellt. Gemäss der Roadmap 2015 und in Übereinstimmung mit seiner strategischen Planung 2017–2020 unterstützt der **ETH-Rat** in der Periode 2017–2020:

- die Infrastrukturen, die Teil des Roadmap-Prozesses 2015 sind:
  - HPCN/HPCN-20 (ETHZ);
  - Aufbau der neuen Strahllinie ATHOS am Freie-Elektronen-Röntgenlaser SwissFEL am PSI;
  - Swiss Light Source SLS 2.0 (PSI);
  - Initiative for Data Science in Switzerland (Swiss Data Science Center) (ETHZ, EPFL);
  - Swiss Plasma Center (EPFL);
  - Next Evolution in Sustainable Building Technologies (NEST) (Empa), Eawag);

- die anderen Infrastrukturen ausserhalb des Roadmap-Prozesses 2015:
  - Optimierung des CMS-Detektors im CERN (unter der Leitung der ETHZ);
  - Blue Brain Project der EPFL (Teil des europäischen Flagship-Projekts Human Brain. Project).

Die oben erwähnte Weiterentwicklung der bestehenden FIS und die Schaffung neuer Infrastrukturen im Rahmen der BFI-Botschaft 2017–2020 kostet im ETH-Bereich rund 531 Mio. CHF (davon etwa 452 Mio. zulasten des Bundes).

Die Infrastrukturen der **kantonalen Hochschulen** werden hauptsächlich von den Institutionen finanziert und subsidiär vom Bund über Grundbeiträge gemäss dem Hochschulförderungs- und -koordinationsgesetz (HFKG) unterstützt. Die von den kantonalen Hochschulen in der Periode 2017−2020 geplanten und in der Roadmap 2015 aufgeführten FIS sind in Anhang A2 beschrieben.

Das **SBFI** hat im Rahmen der Unterstützung nach **Artikel 15 FIFG** (Beiträge an Forschungseinrichtungen von nationaler Bedeutung) Förderbeiträge für folgende in der Roadmap angemeldete Vorhaben gesprochen:

- die Serviceplattform in der klinischen Forschung Swiss Clinical Trial Organisation (SCTO; einschliesslich des Schweizer Netzwerks der Pädiatrischen Forschungszentren SwissPedNet und des europäischen Pädiatrischen Netzwerks EPCTRI[3]);
- Neue Technologiekompetenzzentren:
    - Balgrist Campus Zürich (Plattformen im Bereich der Orthopädie) und
    - sitem insel Bern (Infrastruktur im Bereich translationaler Medizin).

Die Kosten zulasten des SBFI für die drei oben erwähnten Infrastrukturen belaufen sich für die Periode 2017–2020 auf rund 55 Mio. CHF.

Weitere Massnahmen des Bundes zur Finanzierung der Forschungsinfrastrukturen (Periode 2017−2020).
Die Forschungsförderinstitutionen haben ihre in der Roadmap 2015 beschriebenen Planungen präzisiert.

Der **Schweizerische Nationalfonds** (SNF) hat für die BFI-Periode 2017–2020 im Rahmen der Portfolioüberprüfung seine Fördergrundsätze bei Forschungsinfrastrukturen präzisiert und dabei festgelegt, dass Beiträge an neue Forschungsinfrastrukturen als Anschubfinanzierung von in der Regel maximal zehn Jahren gelten. Dies unter der Bedingung, dass die Folgefinanzierung durch eine Trägerorganisation gesichert ist. Da dieser Grundsatz in der laufenden Förderperiode 2017–2020 nicht vollständig umgesetzt werden kann, waren weitere Klärungen notwendig[4].

Der SNF unterstützt in der laufenden Periode weiterhin verschiedene international verankerte Forschungsinfrastrukturen in den Bereichen Umwelt, Klimaforschung, Medizin sowie Geistes- und Sozialwissenschaften[5]. Auf Programmebene unterstützt der SNF die Hochschulen bei der Finanzierung der Investitionskosten mit dem etablierten Programm R'Equip (zwecks Unterstützung von Forschungsapparaturen) und dem Programm Funding Large international Research projects (FLARE[6]).

Aus den Mitteln im Rahmen der BFI-Botschaft 2017–2020 unterstützt der SNF die Forschungsinfrastrukturen mit einem Betrag in der Höhe von rund 232 Mio. CHF (einschliesslich FLARE).

Die **Akademien der Wissenschaften Schweiz** unterstützen aus den Mitteln im Rahmen der BFI-Botschaft 2017–2020 die «Langzeitunternehmen»[7] (SAGW) und die wissenschaftlichen Sekretariate (SCNAT) mit einem Betrag in der Höhe von 43,6 Mio. CHF. In der laufenden BFI-Periode erfolgte zudem der Transfer der Förderzuständigkeit von acht Editionen vom SNF zur SAGW, wobei die Fördermittel in der Höhe von 10,6 Mio. CHF in der Periode 2017–2020 beim SNF eingestellt bleiben.

Im Weiteren hat der Bund (SBFI) in der laufenden BFI-Periode eine **Nationale Förderinitiative «Personalisierte Medizin»** lanciert und die Schweizerische Akademie der medizinischen Wissenschaften (SAMW) mit dem Aufbau einer nationalen Dateninfrastruktur im klinischen Bereich beauftragt. Diese Initiative (SPHN)[8] wird als Verbundaufgabe zwischen Hochschulen und Universitätsspitälern und dem Förderorgan SNF sowie in Abstimmung mit der Initiative des ETH-

[3] EPCTR (European Paediatric Clinical Trial Research Infrastructure) wurde in das übergeordnete europäische Netzwerk für klinische Studien ECRIN integriert.

[4] Ein Ergebnis der Portfoliobereinigung war auch der Transfer langfristiger Editionen vom SNF an die Schweizerische Akademie der Geistes- und Sozialwissenschaften (SAGW).

[5] s. Kap. 7.

[6] Mit FLARE (Funding Large international Research projects) wird die Konzeption und die Nutzung internationaler Forschungsinfrastrukturen in den Bereichen Teilchenphysik, Astrophysik und Astroteilchenphysik durch die schweizerische Community unterstützt.

[7] DaSCH wird von der SAGW in der Periode 2017–2020 mit 2 Mio. CHF unterstützt.

[8] Swiss Personalized Health Network.

Bereichs zur personalisierten Medizin (PHRT[9] strategischer Schwerpunkt des ETH-Bereichs) umgesetzt.

Die für diese beiden Initiativen zur Verfügung gestellten Mittel belaufen sich auf 70 Mio. CHF für das SBFI und 50 Mio. CHF für den ETH-Rat.

b) Internationale Forschungsorganisationen und Forschungsinfrastrukturen

Die Teilnahme der Schweiz an internationalen Forschungsorganisationen entspricht den Zielsetzungen des Bundesrates, wie er sie in seinem Bericht «Internationale Strategie der Schweiz im Bereich Bildung, Forschung und Innovation» (4. Juli 2018) verabschiedet hat. Als Handlungsleitlinie gilt hier: «Infrastrukturen, Programme und Dienstleistungen vom Ausland stehen Schweizer Akteuren offen und dienen ihnen zur Sicherung und Steigerung der Qualität ihrer eigenen Leistungen».

In Bezug auf die Investitionen in internationale Forschungsinvestitionen ist hervorzuheben, dass die von der Schweiz eingegangenen diesbezüglichen Verpflichtungen völkerrechtlich verbindlich sind. Entsprechend haben neue Vorhaben internationaler Forschungsorganisationen, bei denen die Schweiz bereits Mitglied ist, oberste Finanzierungspriorität. Die Fortsetzung der Beteiligung an internationalen Forschungsorganisationen, denen die Schweiz für eine begrenzte Dauer angeschlossen ist, kommt an zweiter Stelle. Dritte Priorität hat schliesslich der Beitritt der Schweiz zu weiteren bestehenden oder neuen internationalen Forschungsorganisationen

Im Rahmen der BFI-Botschaft 2017–2020 wurden gestützt auf die Roadmap 2015 Beiträge der Schweiz für die Erneuerung der befristeten Beteiligung am Institut Laue-Langevin (ILL) und für die Mitgründung der Organisation Cherenkov Telescope Array (CTA) gesprochen.[10] Auf Investitionen in die in der Roadmap 2015 aufgeführten neuen internationalen Vorhaben SKA, ELI und LBNF-DUNE musste aus finanziellen Gründen oder aufgrund des geringen Reifegrads verzichtet werden. In den letzten drei Jahren sind jedoch die Aufbauarbeiten weiter fortgeschritten und die Projekte soweit gereift, dass eine Neubeurteilung der Bedeutung für die Schweiz in der Periode 2021-2024 erfolgen kann[11].

ESFRI-Vorhaben und Rechtsform ERIC

Schweizer Hochschulen (bzw. Hochschulforschungsinstitute) können im Rahmen ihrer Autonomie sich an Vorhaben des Europäischen Strategieforums für Forschungsinfrastrukturen (ESFRI; European Strategy Forum on Research Infrastructures) beteiligen. Eine direkte Bundeszuständigkeit ist nur dann gegeben, wenn die ESFRI-Vorhaben einen völkerrechtlichen Vertrag erfordern. Dies ist beispielsweise dann der Fall, wenn ein ESFRI-Vorhaben in die Rechtsform eines ERIC (European Research Infrastructure Consortium) überführt wird. Eine Tendenz, die sich in letzter Zeit abzeichnet.

Die ERIC-Rechtsform ist Bestandteil des EU-Rechts. Internationale Forschungsinfrastrukturen, die als ERIC organisiert sind, profitieren von einem stabilen und dauerhaften Organisations- und Rechtsrahmen zur Ausübung ihrer Aktivitäten. In den Staaten, die diese Rechtsform anerkennen, geniessen sie die gleichen Privilegien wie zwischenstaatliche Organisationen. Nicht zuletzt können sich diese internationalen Forschungsinfrastrukturen auch einfacher um Fördermittel der EU bewerben. Aus Sicht der Forschungsförderung des Bundes ist es daher von hoher Priorität, Schweizer Forschungsinstitutionen und Forschergruppen den bestmöglichen Zugang zu allen ERIC zu gewährleisten, die von strategischem Interesse sind. Dieses Ziel erfordert in der Regel jedoch eine Teilnahme an einem ERIC der Schweiz als Mitglied.

Um aber Mitglied eines ERIC werden zu können, muss ein Staat der Europäischen Kommission eine Erklärung vorlegen, in der er die EU-Verordnung über die Errichtung dieser Rechtsform für das betreffende Konsortium anerkennt. In der Schweiz und mit den heutigen gesetzlichen Grundlagen muss diese Anerkennung des ERIC-Rechtsrahmens in jedem einzelnen Fall vom Parlament gutgeheissen werden.

[9] Personalized Health and Related Technologies.
[10] S. Kap. 7.2.
[11] S. Kap. 7.2.

Die ESFRI-Vorhaben mit Schweizer Beteiligung in der Periode 2017−2020 (grundsätzlich Beobachterstatus, ohne völkerrechtliche Verbindlichkeit), die in die ERIC-Rechtsform überführt wurden (Stand 31.12.2018), sind nachfolgend aufgelistet:

Biomedizinische / klinische Forschung:

- **BBMRI ERIC**: Vernetzung von Biodatenbanken; CH-Knotenpunkt: Swiss Biobanking Platform (Unterstützung im Rahmen des SNF-Budgets).
- **ECRIN ERIC**: Vernetzung von Zentren für klinische Studien; CH-Knotenpunkt: Swiss Clinical Trial Organisation (SCTO, Unterstützung im Rahmen des SNF-Budgets).
- **ELIXIR:** Bioinformatikstrukturen im Rahmen von EMBL[12]; CH-Knotenpunkt: Swiss Institute for Bioinformatics (SIB, Bundesbeitrag gemäss Art. 15 FIFG und Art. 28 FIFG / Verpflichtungskredit für Internationale Zusammenarbeit in der Forschung; keine ERIC-Rechtsform; staatsvertragliche Verpflichtung der Schweiz in der BFI-Periode 2013−2016).

Materialforschung und Forschung in den Life Sciences:

- **European Spallation Source ERIC (ESS ERIC):** Neutronenquelle für die Materialforschung und Forschung in den Life Sciences in Lund (Schweden), die zum weltweit leistungsfähigsten Instrument dieser Art werden soll; staatsvertragliche Verpflichtung der Schweiz in der BFI-Periode 2013−2016.

Umwelt-/Klimaforschung:

- **ICOS ERIC:** Atmosphärenphysik und Forschung über die Ökosysteme; CH-Knotenpunkt: ETHZ und HFSJG[13] (Unterstützung im Rahmen des SNF-Budgets und Eigenleistungen der Institutionen des ETH-Bereichs).
- **EPOS ERIC:** Erdbebenforschung; CH-Knotenpunkt: ETHZ / SED[14] (ETH-Bereich und andere).
- **ECCSEL ERIC:** Verschiedene FIS für die Forschung zum Ausscheiden, Speichern und Nutzen von Kohlendioxid zur Energiegewinnung (ETH-Bereich und andere).[15]

Geistes- und sozialwissenschaftliche Forschung:

- **ESSurvey ERIC:** Sozialwissenschaftliche Langzeiterhebungen; CH-Knotenpunkt: FORS[16] (Unterstützung im Rahmen von Art. 15 FIFG).
- **CESSDA ERIC:** Vernetzung der sozialwissenschaftlichen Datenarchive; CH-Knotenpunkt: FORS (Unterstützung im Rahmen von Art. 15 FIFG).
- **SHARE ERIC:** Sozialwissenschaftliche Langzeiterhebungen; CH-Knotenpunkt: IEMS[17] und FORS (Unterstützung im Rahmen von Art. 15 FIFG).
- **DARIAH ERIC**: Europäischer Verbund von digitalen Forschungsinfrastrukturen im Bereich Geisteswissenschaften (Hochschulen sind Mitglied als Konsortialpartner, keine formelle Vertretung auf ministerieller Ebene)[18].

[12] European Molecular Biology Laboratory.
[13] High Altitude Research Stations Jungfraujoch & Gornergrat.
[14] Schweizerischer Erdbebendienst (Swiss Seismological Service).
[15] Eine Erneuerung des Beobachterstatus für ECCSEL ERIC ist für 2020 vorgesehen.
[16] Schweizer Kompetenzzentrum für Sozialwissenschaften (Fondation suisse pour la recherche en sciences sociales, FORS).
[17] Institut d'économie et de management de la santé (IEMS), Universität Lausanne.
[18] Es gibt noch keine formelle Vertretung der Schweiz. Sieben Schweizer Hochschulen und die SAGW sind derzeit als Konsortialpartner an DARIAH beteiligt.

3. Schweizer Roadmap Forschungsinfrastrukturen 2019

3.1. Ziel und Inhalt gemäss FIFG

Die vorliegende Roadmap liefert einen Überblick einerseits über die neu geplanten FIS (s. Anhang A1) und andererseits über den Stand der Entwicklung von Infrastrukturvorhaben, die in der Roadmap 2015 vorgesehen waren (Anhang A2). Damit fungiert sie als Instrument für eine kohärente Abstimmung zwischen nationaler und internationaler Forschungsförderung gemäss dem gesetzlichen Auftrag (Art. 41 FIFG und Art. 55 V-FIFG).

Die vorliegende Roadmap basiert auf der europäischen, d.h. der folgenden Definition von «Forschungsinfrastruktur»:

- Die FIS leistet einen wesentlichen Beitrag zur Entwicklung eines Wissens- bzw. Forschungsgebiets (wissenschaftlicher Mehrwert).
- Die FIS wird von den Forschenden in der Schweiz intensiv genutzt (nationale Bedeutung).
- Der Zugang zur FIS ist für die nationale und internationale Forschungsgemeinschaft geregelt.
- Die FIS können an einem einzigen Standort situiert oder in einem Netzwerk mit mehreren Standorten mit zentraler Managementstruktur organisiert sein.
- Eine FIS verfolgt primär keine autonome Forschung, sondern steht den Forschenden für ihre Projekte zur Verfügung.

Ausserdem muss die Infrastruktur die folgenden Kriterien erfüllen[19] (neu gegenüber der Roadmap 2015):

- Es handelt sich um eine neue FIS oder um ein substanzielles Upgrade einer bestehenden FIS.
- Es handelt sich um eine FIS, deren Reifegrad weit fortgeschritten ist und die kurz vor der Umsetzung steht.
- Die Gesamtkosten der FIS (Investitions- und Betriebskosten) liegen für die Periode 2021–2024 bei mindestens 5 Mio. CHF.

Charakteristisch ist, dass FIS in der Schweiz mittel- bis langfristig (in der Regel über zehn Jahre) aufgebaut bzw. implementiert werden. Damit überschreiten sie den Planungshorizont einer einzelnen BFI-Botschaft.

3.2. Zuständigkeiten und Verfahrensablauf

3.2.1. Zuständigkeiten

Gemäss FIFG sind primär die Hochschulen und die Forschungsanstalten des ETH-Bereichs für die Unterstützung von FIS (d.h. für die Finanzierung) zuständig. Dem SNF kommt eine subsidiäre Rolle zu, indem er FIS fördert, die der Entwicklung von Fachgebieten in der Schweiz dienen. Der Bund seinerseits ist für die subsidiäre Förderung von Forschungsinfrastrukturen von nationaler Bedeutung sowie für Beteiligungen der Schweiz an international koordinierten FIS zuständig (s. Kap. 5.1).

[19] Schweizer Roadmap für Forschungsinfrastrukturen 2019 (im Hinblick auf die BFI-Planung 2021–2024) – Zielsetzung, Prozess und Kriterien: ein Leitfaden.

3.2.2. Verfahrensablauf

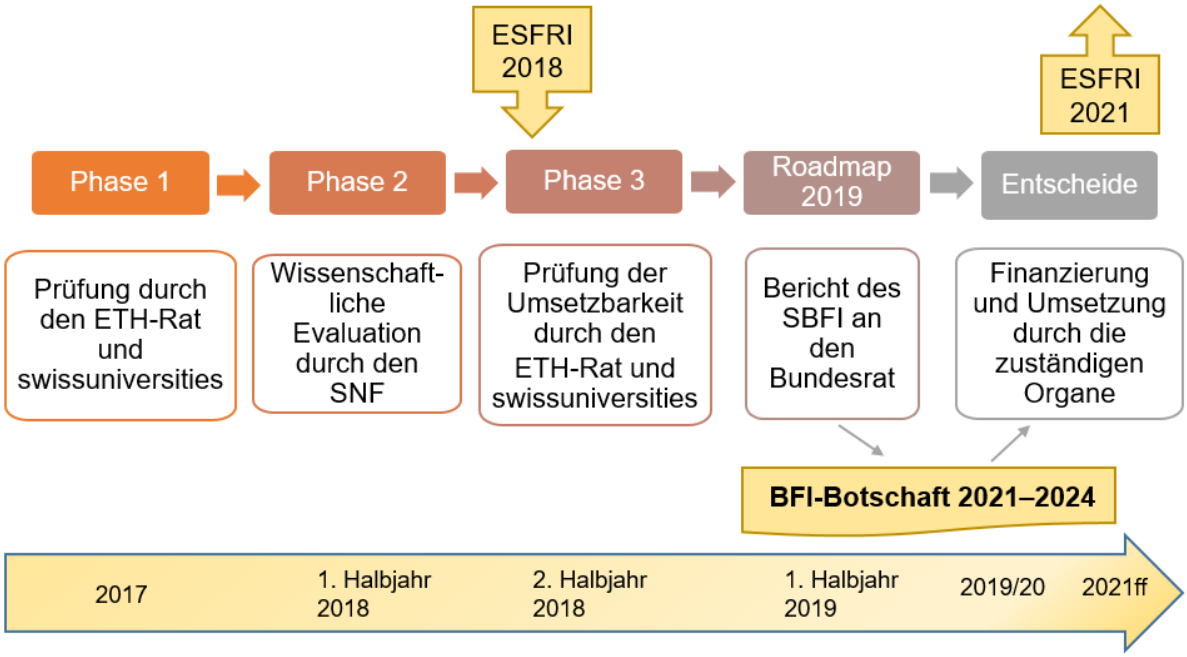

Abbildung 3.1: Verfahrensablauf für neue nationale Infrastrukturvorhaben.

a) Neu geplante nationale Forschungsinfrastrukturen

Phase 1: Die zuständigen Organe (swissuniversities und der ETH-Rat) haben zwischen Januar und Oktober 2017 die neu geplanten FIS erhoben (Vorselektion, s. Kapitel 4).

Phase 2: Die zweite Phase umfasste eine wissenschaftliche Evaluation der in Phase 1 ausgewählten Infrastrukturen durch den SNF (2. Evaluationsstufe). Aus dieser Evaluation ging eine Priorisierung gemäss den in Kapitel 4 beschriebenen Kriterien hervor. Nur FIS-Vorhaben der höchsten Qualitätsstufe («A») wurden für das weitere Prüfverfahren berücksichtigt. Die Beurteilung durch den SNF führte somit zu einer neuen Auswahl.

Phase 3: Die der Stufe «A» zugeordneten Infrastrukturvorhaben wurden von den zuständigen Organen einer vertieften Prüfung unterzogen, wobei auch die Umsetzbarkeit der Vorhaben untersucht wurde (Governance, Management, Finanzierung). Eine detaillierte Beschreibung der einzelnen Infrastrukturen ist in Anhang A1 zu finden.

b) Aktualisierung der Daten zu den nationalen FIS der Roadmap 2015

Zwischen Juli und November 2018 wurden bei den zuständigen Stellen (swissuniversities und ETH-Rat) die aktuellen Daten zu den 23 Schweizer FIS eingeholt, die gemäss der Roadmap 2015 neu geplant waren. Die aktualisierten Informationen sind in Anhang A2 zu finden.

c) Aktualisierung der Daten zu den internationalen Organisationen und ESFRI-Vorhaben

Die Daten zur Aktualisierung der Informationen über die internationalen Infrastrukturen und Organisationen wurden vom SBFI erhoben und vom SNF für seine Stellungnahmen verwendet (s. Kapitel 7 und Anhang B2).

4. Erste und zweite Evaluationsstufe (Phasen 1 und 2): Erhebungs- und Beurteilungsverfahren

4.1. Beurteilungsverfahren und -kriterien

Der ETH-Rat und swissuniversities haben bei ihren jeweiligen Institutionen eine Erhebung durchgeführt, um Vorschläge für neue FIS-Vorhaben zu ermitteln, einschliesslich substanzielle Upgrades. In einem ersten Schritt wurden die «Skizzen» zu den neuen Infrastrukturen, die von den Trägerinstitutionen (Hochschulen und Forschungsanstalten des ETH-Bereichs) eingereicht wurden, auf ihre Kohärenz mit der strategischen Planung der beteiligten Hochschulen sowie hinsichtlich den in Kapitel 3.1 definierten Zulassungsvoraussetzungen überprüft.

Ergebnis der Evaluation (1. Evaluationsstufe): Es wurden 17 neue Projekte ausgewählt. Im Auftrag des SBFI beurteilte der SNF schliesslich 15[20] davon (2. Evaluationsstufe), wobei er sich auf die folgenden Kriterien abstützte:

- Qualität der Infrastruktur, der Forschung und der beteiligten Forschenden
- Wissenschaftliche Bedeutung
- Zugänglichkeit und Benutzergruppen
- Wissenschaftliche Umsetzbarkeit

Die Ergebnisse der Evaluation durch den SNF lassen sich in drei Kategorien einteilen:

Priorität A	Hohe wissenschaftliche Bedeutung	7 Projekte
Priorität B	Mittlere wissenschaftliche Bedeutung	7 Projekte
Priorität C	Geringe wissenschaftliche Bedeutung	1 Projekt

4.2. Übersicht nach Bereichen und Institutionen

Die 15 vom SNF geprüften FIS verteilen sich wie folgt auf die vier grossen Bereiche (Abb. 4.1):

- Geistes- und Sozialwissenschaften: 3
- Mathematik, Ingenieur- und Naturwissenschaften (MINT): 8
- Life Sciences: 3
- e-Infrastrukturen: 1

Folgende Trägerinstitutionen reichten neue Vorhaben ein:

- ETH-Bereich: 6
- Kantonale Universitäten: 8
- Fachhochschulen: 1

Das Finanzvolumen aller 15 neuen FIS wurde auf rund 708 Mio. CHF geschätzt (Gesamtkosten für die Periode 2021–2024 mit Investitions- und Betriebskosten, Stand August 2018).[21] Die nachstehende Abbildung 4.2 zeigt die Verteilung dieser Kosten auf die vier grossen wissenschaftlichen Bereiche, während Abbildung 4.3 eine Übersicht über die Verteilung des Finanzvolumens auf die Priorisierungskategorien A, B und C vermittelt.

Die geprüften Vorhaben verteilen sich über alle Fachbereiche, wobei der MINT-Bereich den grössten Anteil ausmacht (Abb. 4.1). Bei der Verteilung des Finanzvolumens nach Bereichen (Abb. 4.2) zeigt sich deutlich, dass der MINT-Bereich die höchsten Kosten ausweist. Auffallend ist, dass der Bereich e-Infrastrukturen nur gerade ein Vorhaben umfasst, aber 24 Prozent der Kosten ausmacht. Bezüglich der Verteilung der Kosten nach Priorisierungskategorien ist festzustellen, dass fast zwei Drittel der geplanten Kosten auf die A-priorisierten Vorhaben entfallen (Abb. 4.3).

[20] Dass es schliesslich nur 15 von insgesamt 17 waren, ist darauf zurückzuführen, dass ein Vorhaben des ETH-Rates dem SNF nicht vorgelegt wurde. Zudem wurde ein Vorhaben von swissuniversities nach der Unterbreitung an den SNF zurückgezogen.

[21] Dieser Finanzbedarf wurde im Rahmen der vertieften Evaluation (3. Evaluationsstufe) erhöht, bestätigt oder reduziert und unter finanztechnischen Klärungen präzisiert.

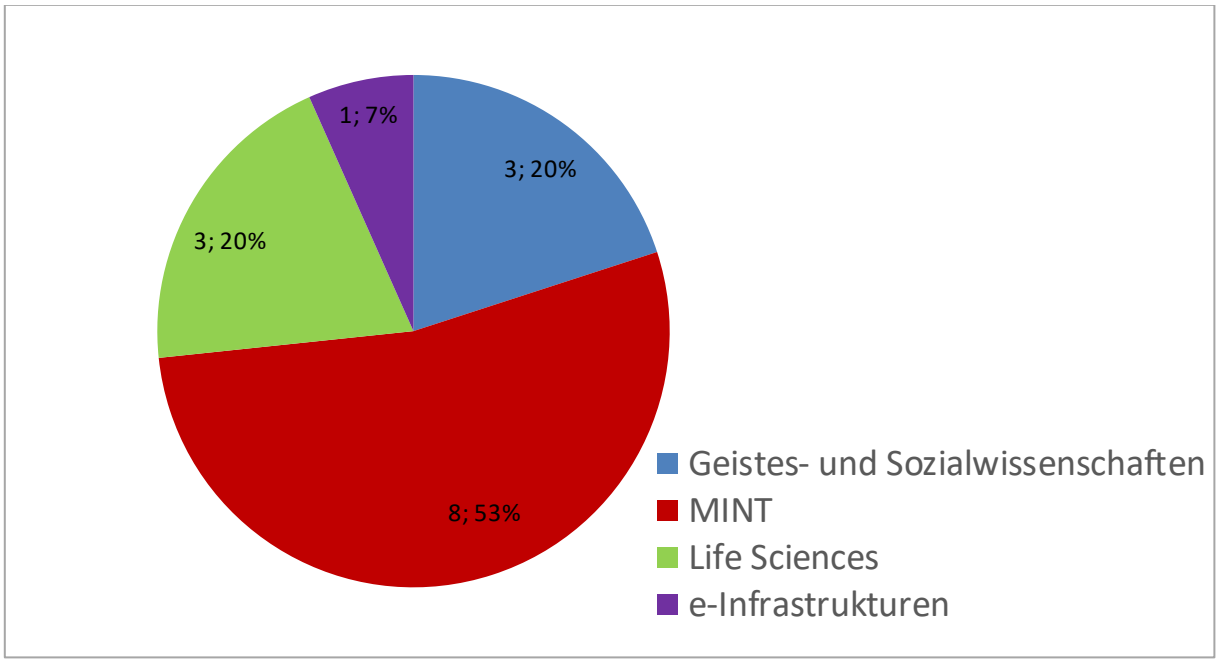

Abbildung 4.1: Verteilung nach Bereichen (n = 15 Projekte).

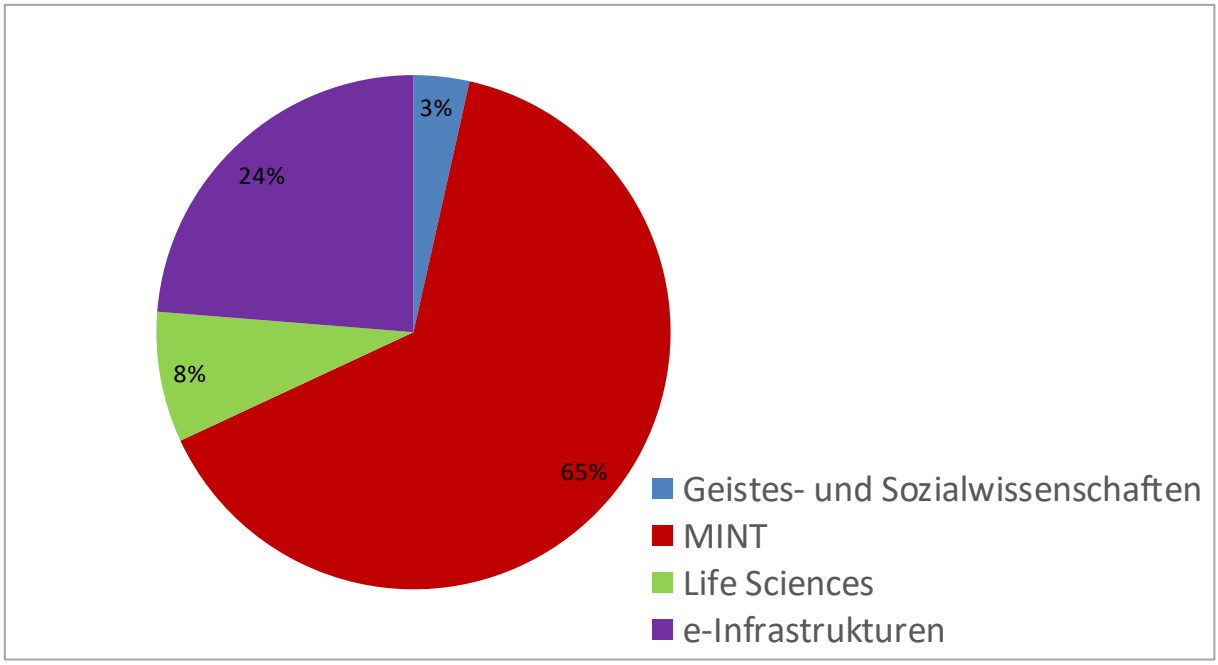

Abbildung 4.2: Verteilung der Finanzmittel nach Bereichen (n = 15 Projekte für insgesamt 708 Mio. CHF).

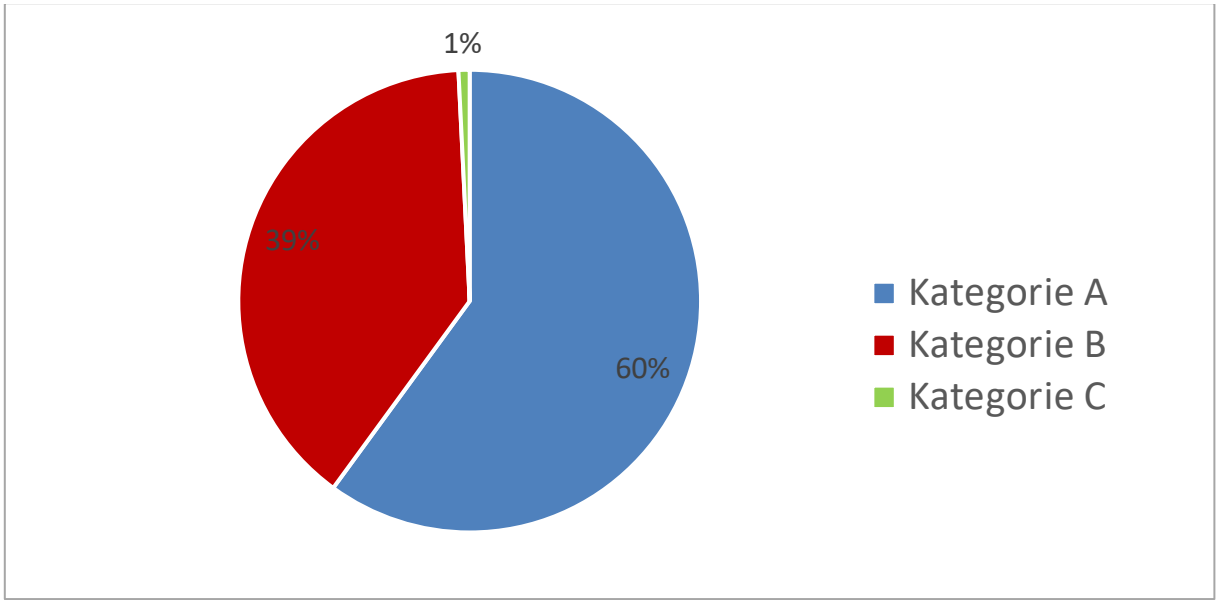

Abbildung 4.3: Verteilung der Finanzmittel nach Priorität (n = 15 Projekte für insgesamt 708 Mio. CHF).

5. Dritte Evaluationsstufe (Phase 3): Prüfung durch die zuständigen Organe

5.1. Verteilung der Aufgaben

Gemäss Bundesgesetz über die Förderung der Forschung und der Innovation (FIFG) sind primär die Hochschulen bzw. deren Träger für die Unterstützung und Finanzierung von FIS zuständig. Den Forschungsförderorganen des Bundes (SNF, Akademien) kommt bei der Unterstützung von FIS eine subsidiäre Rolle zu (Art. 10 Abs. 3 Bst. c und Art. 11 Abs. 6 FIFG). Der Bund seinerseits ist für die subsidiäre Förderung von Forschungsinfrastrukturen von nationaler Bedeutung (Art. 15 FIFG) sowie für völkerrechtlich geregelte Beteiligungen der Schweiz an international koordinierten FIS nach Artikel 28 FIFG zuständig.

Im ETH-Bereich sind der ETH-Rat sowie die beiden Hochschulen ETHZ und EPFL und die vier Forschungsanstalten (PSI, WSL, Empa und Eawag) im Rahmen des ETH-Gesetzes und der strategischen Ziele des Bundesrates für den ETH-Bereich (auch durch Drittmittel) verantwortlich für die Realisierung ihrer Forschungsinfrastrukturen. Bei den kantonalen Universitäten und Fachhochschulen erfolgt eine Beteiligung des Bundes an der Finanzierung der Forschungsinfrastrukturen nach dem Bundesgesetz über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich (HFKG) subsidiär über die Grundbeiträge. Projektgebundene Beiträge (Art. 59 Abs. 2 HFKG) ermöglichen in erster Linie eine zeitlich beschränkte Finanzierung von Kooperationsprojekten, die für das gesamte Hochschulsystem von Bedeutung sind und die sich im Wesentlichen auf die Lehre und das Studienangebot beziehen.

Unter Berücksichtigung der obigen Beschreibung fielen alle 15 Vorhaben, die vom SNF in der Phase 2 geprüft wurden, entweder in die Zuständigkeit des ETH-Rates (sechs Projekte) oder von swissuniversities (neun Projekte, davon acht von kantonalen Universitäten und eines einer Fachhochschule).

Beide zuständigen Organe führten für die Vorhaben, die der SNF der Kategorie A zugewiesen hat (insgesamt sieben Projekte), die 3. Evaluationsstufe nach ihrem eigenen Verfahren durch, wobei sie sich an den gemeinsamen Kriterien orientierten und Planung, Governance und Management ebenso wie Finanzen und Unterstützung der Institutionen prüften.

5.2. Vertiefte Prüfung: Umsetzbarkeit (Finanzierung, Planung, Governance und Management) – Ergebnisse

Nach Ablauf der Phase 3 der Evaluation haben die verantwortlichen Organe sieben Projekte, die der SNF der Kategorie A (hohe wissenschaftliche Bedeutung) zugewiesen hat, für eine vertiefte Prüfung hinsichtlich ihrer Umsetzung empfohlen. Tabelle 5.1 zeigt eine Übersicht dieser A-priorisierten FIS in der Reihenfolge ihres Finanzvolumens. Die geschätzten Gesamtkosten für die Periode 2021–2024 belaufen sich auf rund 412,82 Mio. CHF, wovon 366,9 Mio. auf den Bund entfallen (Stand Januar 2019). Abbildung 5.1 zeigt die Verteilung der Kosten nach wissenschaftlichen Bereichen für die sieben vorgeschlagenen Vorhaben. Dabei fällt auf, dass die drei Bereiche e-Infrastrukturen, Geistes- und Sozialwissenschaften sowie Life Sciences alle nur ein Vorhaben aufweisen, während der MINT-Bereich deren vier umfasst.

Tabelle 5.1: Priorisierte Infrastrukturen und Kosten für die Periode 2021−2024

Bereich	Institution	Projekt	Gesamtkosten (Mio. CHF)[22]	Kosten Bund (Mio. CHF)[23]
e-Infrastrukturen	ETHZ	High-Performance Computing and Networking Infrastructure (HPCN-24)	174,00	162,00
MINT	PSI	Swiss Light Source SLS 2.0	167,00	167,00
MINT	EPFL & ETHZ	Catalysis Hub (CAT+)	32,70	31,90
Life Sciences	Universität Zürich	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	18,00	6,00[24]
MINT	Universität Zürich	Airborne Research Facility for the Earth System (ARES)	9,22	-
Geistes- und Sozialwissenschaften	Universität Zürich	Linguistic Research Infrastructure (LiRI)	6,80	-
MINT	Universität Zürich	Center of Structural Electron Microscopy (COSEM)	5,10	-
		Total	**412,82**	**366,9**

Anhang A1 der vorliegenden Roadmap liefert eine detaillierte Beschreibung dieser vorgeschlagenen Forschungsinfrastrukturen.

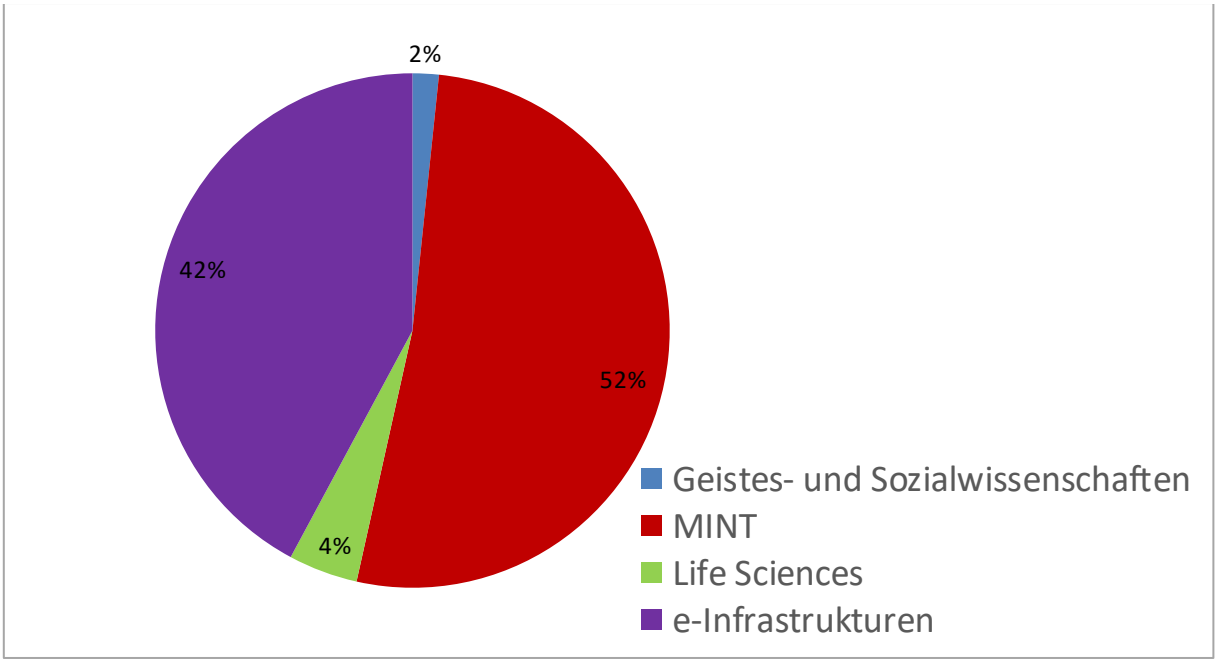

Abbildung 5.1: Verteilung der Finanzmittel nach Bereichen (n = 7 empfohlene Vorhaben für insgesamt 412,82 Mio. CHF)

a) ETH-Bereich (Stand Januar 2019)

Gemäss der Planung des ETH-Rats[25] kommt den in Tabelle 5.2 aufgeführten FIS eine besondere strategische Bedeutung zu. Nach positiven Beurteilungen unterstützt der ETH-Rat die Aufnahme der drei in dieser Tabelle genannten Projekte in die Roadmap.

[22] Das detaillierte Budget ist in Anhang A1 zu finden.

[23] Die «Kosten Bund» umfassen die Institutionen des ETH-Bereichs und den ETH-Rat. Die kompetitiv vergebenen Mittel des SNF (z. B. R'Equip-Beiträge) sind hingegen nicht enthalten.

[24] Beitrag der ETHZ.

[25] Strategische Planung 2021–2024 des ETH-Rates für den ETH-Bereich, 2019.

Tabelle 5.2: Priorisierte Infrastrukturen des ETH-Bereichs

N°[26]	Bezeichnung FIS	Hauptverantwortliche Trägerinstitution	Geschätzter Mittelbedarf 2021–2024 (in Mio. CHF)	Mittelbedarf zulasten Zahlungsrahmen ETH-Bereich (in Mio. CHF)
1	High-Performance Computing and Networking (HPCN-24)	ETH-Rat (ETHZ)	174,0	162,0
2	Swiss Light Source SLS 2.0	ETH-Rat (PSI)	167,0	167,0
3	Catalysis HUB (CAT+)	ETH-Rat (EPFL & ETHZ)	32,7	31,9
		Total	**373,7**	**360,9**

Für die vollständige Realisierung der drei FIS (zwei Upgrades, ein neues Vorhaben) ergibt sich für die Periode 2021–2024 ein geschätzter Mittelbedarf von insgesamt 373,7 Mio. CHF. Zu dessen Deckung sind 360,9 Mio. CHF (davon 216 Mio. CHF durch den ETH-Rat) aus dem Zahlungsrahmen des ETH-Bereichs bereitzustellen. Sofern der ETH-Bereich die Finanzierung nicht aus dem für ihn bestimmten und vom Parlament zu beschliessenden Zahlungsrahmen für die Jahre 2021–2024 sicherstellen kann, wird der ETH-Rat zu gegebenem Zeitpunkt über die Realisierung bzw. die Finanzierungsmodalitäten der Vorhaben im Rahmen seiner finanziellen Möglichkeiten entscheiden.

Neben den Investitionen in neue FIS werden während der BFI-Periode 2021–2024 massgebliche Mittel für den Betrieb sowie für die Weiterentwicklung bzw. den Ausbau von bestehenden FIS bereitgestellt. So sieht der ETH-Rat in seiner strategischen Planung 2021–2024 Beiträge für die Weiterentwicklung des Neuroinformatikprojekts Blue Brain der EPFL in der Höhe von 88 Mio. CHF vor.

Ergebnis:

- Für die drei oben aufgeführten FIS würden dem Bund (als Träger des ETH-Bereichs) für die BFI-Periode 2021–2024 Kosten in der Höhe von 360,9 Mio. CHF entstehen.
- Die Höhe der zur Verfügung stehenden Finanzmittel wird über den ETH-Finanzrahmen in der BFI-Botschaft 2021–2024 festgelegt bzw. beantragt.
- Die Entscheidung, ob und in welchem Umfang diese FIS in der Periode 2021–2024 umgesetzt werden, obliegt dem ETH-Rat bzw. den Institutionen des ETH-Bereichs.

[26] Für detaillierte Informationen s. Anhang A1. Die Vorhaben sind dort gemäss dieser Nummerierung aufgeführt.

b) Kantonale Hochschulen (Stand Januar 2019)

Nach einer positiven Beurteilung und gemäss den strategischen Planungen der kantonalen Hochschulen hat swissuniversities die folgenden vier Vorhaben zur Umsetzung vorgeschlagen:

Tabelle 5.3: Priorisierte Infrastrukturen der kantonalen Hochschulen

N°[27]	Bezeichnung FIS	Hauptverantwortliche Trägerinstitution	Geschätzter Mittelbedarf 2021–2024 (in Mio. CHF)	Mittelbedarf zulasten des Bundes (in Mio. CHF)
4	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	Universität Zürich	18,00	6,00[28]
5	Airborne Research Facility for the Earth System (ARES)	Universität Zürich	9,22	-
6	Center of Structural Electron Microscopy (COSEM)	Universität Zürich	5,10	-
7	Linguistic Research Infrastructure (LiRI)	Universität Zürich	6,80	-
		Total	**39,12**	**6,00**

Der Gesamtmittelbedarf für die vollständige Realisierung dieser vier FIS wird auf rund 39,12 Mio. CHF geschätzt. Für keines der Projekte wurde von swissuniversities ein Antrag für projektgebundene Beiträge eingereicht.

Ergebnis:

- Bei einer vollständigen Realisierung dieser neuen FIS würden dem Bund aufgrund des Beitrags der ETHZ Kosten in der Höhe von insgesamt 6 Mio. CHF entstehen (Projekt 1.2 GHz NMR).
- Die Entscheidung, ob und in welchem Umfang diese neuen FIS in der BFI-Periode 2021–2024 umgesetzt werden, obliegt den zuständigen Universitäten.

c) Bund

Der Bund ist für keines der in der Kategorie A klassierten Projekte direkt zuständig. Gesuche für Beiträge an Forschungseinrichtungen von nationaler Bedeutung (Art. 15 FIFG) sind Gegenstand eines unabhängigen Verfahrens, wobei die Gesuchstellerinnen und Gesuchsteller ihr Vorhaben bis am 30. Juni 2019 einreichen müssen (Art. 12 V-FIFG-WBF, SR 420.111). Diese Vorhaben werden vom Schweizerischen Wissenschaftsrat geprüft und der Entscheid des WBF wird Ende 2020 gefällt.

[27] Für detaillierte Informationen s. Anhang A1. Die Vorhaben sind dort gemäss dieser Nummerierung aufgeführt.
[28] Beitrag der ETHZ.

6. Von den Förderorganen des Bundes finanzierte Forschungsinfrastrukturen

Neben der hauptgewichtigen Zuständigkeit der Hochschulen und der Forschungsanstalten des ETH-Bereichs bzw. deren Trägerschaften für die Finanzierung von FIS haben auch die Förderorgane des Bundes, namentlich der SNF und die Akademien, gemäss FIFG eine subsidiäre Förderaufgabe in diesem Bereich. Sie haben im Rahmen ihrer Mehrjahresprogramme 2021–2024 ihre Planungen bereits eingereicht.

6.1. SNF

Die Unterstützung von FIS durch den SNF erfolgt in der Regel aufgrund spezifischer, zweckgebundener und zeitlich begrenzter finanzieller Zusprachen.

In der Periode 2021−2024 wird der SNF sein Portfolio mit Dateninfrastrukturen (und -repertorien) von nationaler Bedeutung erweitern, die für die wissenschaftliche Forschung unerlässlich sind. Diese Infrastrukturen, die für einzelne Institutionen zu teuer sind, leisten der Forschergemeinschaft in der Schweiz und im Ausland dank des transparent geregelten Zugangs und der Interoperabilität der Daten wertvolle Dienste.

Es bestehen verschiedene Typen von Dateninfrastrukturen (und -repertorien), weshalb spezifische und für die zahlreichen Dateninfrastrukturen geltende Evaluationskriterien aufgestellt werden müssen. Der SNF schlägt daher vor, seine Aktivitäten in diesem Bereich in der Periode 2021−2024 schrittweise auszubauen.

Ab 2021 ist der SNF für die Finanzierung und die Evaluation der bestehenden Infrastrukturen FORS und DaSCH sowie für die Kohorten (darunter die beiden Kohorten Swiss HIV cohort study [SHCS] und Swiss transplant cohort study [STCS], die für das Bundesamt für Gesundheit hohe Priorität haben) zuständig. Im Allgemeinen werden die Kohorten mit den vorhandenen Instrumenten zur Forschungsförderung unterstützt.

Um dem steigenden Bedarf an spezialisierten Dateninfrastrukturen (zusätzlich zu den bestehenden Infrastrukturen von nationaler Bedeutung) gerecht zu werden, sieht der SNF Anschubfinanzierungen («Start-up grants») und Finanzierungen für Entwicklungsvorhaben von Datenstrukturen vor, die möglicherweise nationale Bedeutung erlangen könnten. Die Finanzierung von Infrastrukturen, die nicht als national bedeutsam angesehen werden, wird auf eine Initialphase von zehn Jahren beschränkt, in Einklang mit der Unterstützungspolitik des SNF für Forschungsinfrastrukturen.

Zudem wird der SNF auch die Programme R'Equip (zur Anschaffung von grösseren Apparaturen) und FLARE (für internationale Forschungsinfrastrukturen in den Bereichen Teilchenphysik, Astrophysik und Astroteilchenphysik) weiterführen.

Im Rahmen des Mehrjahresprogramms 2021−2024 plant der SNF, folgende Programme und Infrastrukturen zu unterstützen:

Forschungsinfrastrukturen	**Budget 2021-2024** in Mio. CHF (gemäss Mehrjahresprogramm)
a) Instrumente	
Forschungsinfrastrukturen und R'Equip	115,1
b) Förderung von Dateninfrastrukturen gemäss Mandat Bund (SBFI)	
FORS (Transfer von Art. 15 FIFG)	32,8
DASCH (Transfer von den Akademien)	9,2
Datenrepositorien/zusätzliche Aktivitäten im Bereich Dateninfrastrukturen[29]	10,0
Kohorten SHCS und STCS	20,0
c) Weitere Finanzierungen (Plattformen)	
SCTO	4,0
Swiss Biobank Platform	4,0
Longitudinalstudien (Kohorten)	32,0
Total	**227,1**

Ergebnis:

- Zusätzlich zu den bestehenden Programmen (z.B. R'Equip) wird der SNF Datenrepertorien und -infrastrukturen sowie Kohorten unterstützen.
- Die Umsetzung bzw. Unterstützung von FIS in der Zuständigkeit des SNF erfolgt im Rahmen der Gesamtmittel, die dem SNF mit der BFI-Botschaft 2021–2024 zur Verfügung gestellt werden (Zahlungsrahmen).

[29] Im Rahmen von Art. 59 HFKG (Projektgebundene Beiträge) werden von swissuniversities 45 Mio. CHF für Datenrepositorien beantragt. Es ist sicherzustellen, dass die vom SBFI verlangte Auslegeordnung zur Situation von Datenrepositorien vorliegt und gestützt darauf die Zielsetzungen für Datenrepositorien in den Hochschulen (inkl. Schwerpunkte der ETH im Bereich der nationalen Initiative Datenzentrum, s. Anhang A2) mit den Aktivitäten des SNF abgestimmt sind sowie die reservierten Mittel beim SNF und bei swissuniversities komplementär (kein Aufbau von Parallelstrukturen) eingesetzt werden.

6.2. Akademien

Im Rahmen des Mehrjahresprogramms 2021–2024 plant die **SAGW** folgende FIS mit einem Budget von 59,69 Mio. CHF zu unterstützen:

Editionen (Transfer vom SNF)	13,15 Mio. CHF
Langzeitunternehmen (Fortsetzung)	46,54 Mio. CHF

Im Rahmen des Mehrjahresprogramms 2021–2024 plant die **SCNAT** die folgenden FIS mit einem Gesamtbudget von 22,84 Mio. CHF zu unterstützen:

Wissenschaftliche Sekretariate (Transfer vom SNF)	8,84 Mio. CHF
Naturwissenschaftliche Sammlungen (neues Projekt)	14,00 Mio. CHF

Im Rahmen des Mehrjahresprogramms 2021–2024 plant die **SAMW** ein Budget von 33 Mio. CHF für:

Initiative SPHN (Fortsetzung)	33,00 Mio. CHF
Total für die Akademien	**115,53 Mio. CHF**

Ergebnis:

- Die Unterstützung von FIS in der Zuständigkeit der Akademien erfolgt im Rahmen der Gesamtmittel, die den Akademien mit der BFI-Botschaft 2021–2024 zur Verfügung gestellt werden (Zahlungsrahmen).

7. Internationale Forschungsinfrastrukturen

7.1. ESFRI-Vorhaben, deren Relevanz für die Schweiz zu prüfen ist

Schweizer Institutionen beteiligen sich an mehreren ESFRI-Vorhaben, ohne direkte Bundeszuständigkeit. Es handelt sich um ESFRI-Vorhaben, welche die ERIC-Rechtsform angenommen haben. Die Schweiz hat für diese Vorhaben einen Beobachterstatus beantragt, der mit keiner völkerrechtlichen Verpflichtung verbunden ist. Die Beteiligung von Schweizer Institutionen an diesen ESFRI-Vorhaben kann jedoch Auswirkungen auf die Investitionen des Bundes in den ETH-Bereich, auf Investitionsbeiträge an Universitäten und Fachhochschulen, auf Beiträge nach Art. 15 FIFG oder auch auf Aufgaben in der Zuständigkeit des SNF oder der Akademien haben.

Das SBFI hat beim SNF Stellungnahmen zu den internationalen FIS in Auftrag gegeben, an denen die Schweiz unter der Trägerschaft der betroffenen Institutionen bereits beteiligt ist. Die nachfolgend aufgeführten Infrastrukturen sind in der ESFRI-Roadmap 2018[30] enthalten.

Im November 2018 hat der SNF seine Stellungnahmen[31] zur nationalen Bedeutung der folgenden Infrastrukturen unterbreitet: eLTER, SILECS, ECCSEL, ACTRIS, ELI, BBMRI, ECRIN, EPOS, ICOS, CESSDA, ESSurvey, SHARE, DARIAH, EST und PRACE. Das SBFI stellte dem SNF die folgenden Fragen, um die nationale Relevanz jeder Infrastruktur zu ermitteln:

- Inwieweit ist eine Schweizer Beteiligung an der internationalen Infrastruktur für die wissenschaftliche Gemeinschaft im Hinblick auf die künftige Entwicklung in der Schweiz unerlässlich?
- Welche Infrastrukturen können entsprechend ihrer Bedeutung für die wissenschaftliche Gemeinschaft in der Schweiz den Kategorien A, B oder C zugeordnet werden (A: hohe Bedeutung; B: mittlere Bedeutung; C: geringe Bedeutung)?

[30] www.esfri.eu/

[31] Hier handelt es sich um eine Einschätzung des SNF zur Bedeutung dieser internationalen Forschungsinfrastrukturen für die Schweiz. ESFRI-Vorhaben wurden auf europäischer Ebene bereits wissenschaftlich beurteilt.

a) Infrastrukturen, an denen Schweizer Institutionen bereits beteiligt sind (2021–2024)

Infrastruktur	Wichtigste beteiligte Schweizer Institution («nationaler Knotenpunkt»)	Priorität für die Schweiz	Ungefähre Kosten für den Bund (SBFI oder SNF) (in Mio. CHF)[32]
European Plate Observing System **(EPOS ERIC)**	ETHZ	A	0,65 (SBFI)
European Clinical Research Infrastructure Network **(ECRIN ERIC)**	SCTO	A	0,22 (SBFI)
Integrated Carbon Observation System **(ICOS ERIC)**	ETHZ	A	0,32 (SNF)
Biobanking and molecular resources research infrastructure **(BBMRI ERIC)**	SBP	A	0,26 (SNF)
Consortium of European Social Science Data Archives **(CESSDA ERIC)**	Universität Lausanne	A	0,13 (SNF)
European Social Survey **(ESSurvey ERIC)**	Universität Lausanne	A	0,43 (SNF)
Survey of Health, Ageing and Retirement in Europe **(SHARE ERIC)**	Universität Lausanne	A	0,10 (SNF)
Partnership for Advanced Computing in Europe **(PRACE)**	ETHZ	A	-
European Carbon Dioxide Capture and Storage Laboratory Infrastructure **(ECCSEL ERIC)**	ETHZ	A	0,26 (SBFI)

b) Infrastrukturen, an denen Schweizer Institutionen interessiert sind

Infrastruktur	Wichtigste beteiligte Schweizer Institution («nationaler Knotenpunkt»)	Priorität für die Schweiz	Ungefähre Kosten für den Bund (SBFI) (in Mio. CHF)[33]
Aerosol, Clouds, and Trace Gases Research Infrastructure **(ACTRIS)**	PSI	A	5,09[34]
Digital Research Infrastructure for the Arts and Humanities **(DARIAH ERIC)**	Konsortium[35]	A	zu bestimmen (SNF)
European Long-Term Ecosystem and socio-ecological Research Infrastructure **(eLTER)**	WSL, ETHZ, Universität Basel	A	-
Extreme Light Infrastructure **(ELI)**	ETHZ	B	-
European Solar Telescope **(EST)**	USI[36]	B	-
Infrastructure for Large-scale Experimental Computer Science **(SILECS)**[37]	Universität Genf	B-C	-

[32] Kosten für die Beteiligung.

[33] Periode 2021−2024.

[34] Der hier angegebene Betrag umfasst auch ein Gesuch der Institutionen (im Wesentlichen der ETHZ) für eine Beteiligung an den Aktivitäten von ACTRIS.

[35] Konsortium bestehend aus den Universitäten Basel, Bern, Genf, Lausanne, Neuenburg und Zürich sowie der EPFL und der SAGW.

[36] Universität der italienischen Schweiz.

[37] SILECS wurde (in Koordination mit Frankreich) für die ESFRI-Roadmap 2018 eingereicht, jedoch nicht berücksichtigt.

Zwölf Infrastrukturen wurde eine hohe Bedeutung für die wissenschaftliche Gemeinschaft der Schweiz zugesprochen (Priorität A). Zwei davon sind in Planung (ACTRIS und eLTER), an einer beteiligen sich noch keine Forschenden der Schweiz (ECCSEL ERIC). Die Infrastrukturen SILECS, EST und ELI sind nicht prioritär (Priorität B/C). Nur die internationalen FIS mit Priorität A werden in Anhang B1 vertieft geprüft und beschrieben.[38]

Ergebnis:

- Das SBFI wird die Möglichkeit einer Beteiligung der Schweiz an den internationalen FIS mit Priorität A im Rahmen der BFI-Botschaft 2021–2024 und unter Berücksichtigung der Stellungnahmen des SNF sowie der nationalen und internationalen politischen und finanziellen Überlegungen (verfügbare Kredite) prüfen.
- Die Kosten einer Beteiligung an einer ESFRI-Infrastruktur werden durch die Eigenleistungen der Hochschulen (Finanz- und Sachleistungen) sowie durch eine subsidiäre Unterstützung durch den Bund in der Höhe von 6,22 Mio. CHF (SBFI) und durch den SNF in der Höhe von 1,24 Mio. CHF (letztere im Rahmen der mit der BFI-Botschaft 2021–2024 zur Verfügung gestellten Gesamtmittel) finanziert.

c) Update der ESFRI-Roadmap 2018

Seit der Veröffentlichung der letzten Schweizer Roadmap 2015 wurden neue Infrastrukturen, für welche Schweizer Institutionen ein Interesse gezeigt haben, in die europäische ESFRI-Roadmap aufgenommen.

- Bestehende FIS (noch kein ERIC):
  - **ACTRIS**: In der nationalen Roadmap 2015 hatte die Schweizer Forschungsgemeinschaft ihr Interesse für eine Beteiligung an dieser FIS angemeldet. Die Abklärungen des SBFI unter Einbezug der Stellungnahme des SNF haben ergeben, dass eine mögliche Beteiligung der Schweiz an ACTRIS in der nächsten BFI-Periode evaluiert wird. Die Frage der Mitgliedschaft wird sich voraussichtlich 2024/25 stellen (bei der geplanten Etablierung der ERIC). ACTRIS wird vom PSI koordiniert und durch ein Konsortium von Hochschulen / Forschungsinstitutionen mitfinanziert.
  - **EST:** Die Abklärungen des SBFI unter Einbezug der Stellungnahme des SNF haben ergeben, dass EST im Moment nicht weiter geprüft wird.

- Überdies hat die Schweizer Forschungsgemeinschaft ihr Interesse an folgender FIS bekundet, die neu in die ESFRI-Roadmap 2018 aufgenommen wurde:
  - **eLTER** (seit 2018 Teil der ESFRI-Roadmap): In der nationalen Roadmap 2015 hatte die Schweizer Forschungsgemeinschaft ihr Interesse für eine Beteiligung angemeldet. Die Prüfung des SBFI und die Stellungnahme des SNF haben ergeben, dass eine mögliche Beteiligung der Schweiz an eLTER in der nächsten BFI-Periode evaluiert wird. Die Frage der Mitgliedschaft wird sich voraussichtlich 2025 stellen (bei der geplanten Etablierung der ERIC). eLTER wird von der WSL koordiniert und von der WSL, der ETHZ und der Universität Basel finanziert.

7.2. Internationale Forschungsorganisationen und -infrastrukturen, an denen die Schweiz als Mitglied auf Regierungsebene beteiligt ist

Die Beiträge an internationale Forschungsinfrastrukturen, an denen die Schweiz als Mitglied auf Regierungsebene beteiligt ist, sind völkerrechtlich verbindlich und sind gebundene Ausgaben. Sie werden im Rahmen der Botschaft zum Voranschlag jährlich dem Parlament beantragt. Dies betrifft die internationalen Forschungsinfrastrukturen CERN, ESO, EMBC/EMBL, ESRF und European XFEL.

Befinden sich Infrastrukturen dieser Kategorie jedoch in der Planungs- oder Bauphase, werden die Schweizer Beiträge über die beantragten Kredite im Rahmen der BFI-Botschaften (European Spallation

[38] ELI war in der Periode 2017–2020 bereits im Prüfverfahren und die Stellungnahme des SNF empfiehlt keinen Abbruch der Prüfung. Diese Infrastruktur wird deshalb in Anhang B1 ebenfalls beschrieben.

Source ERIC, CTA) oder der Botschaft zur Finanzierung der Schweizer Beteiligung an den EU-Rahmenprogrammen (ITER/Fusion for Energy) finanziert. Die Beiträge an Infrastrukturen, an denen sich die Schweiz für eine begrenzte Dauer beteiligt (ILL), werden ebenfalls im Rahmen der BFI-Botschaften beantragt.

Aus den in der Periode 2017−2020 stattfindenden Entwicklungen an diesen Infrastrukturen ergeben sich die folgenden Bedürfnisse für die Periode 2021−2024:

- Eine Verlängerung der Beteiligung der Schweiz am ILL mindestens bis zur vollständigen Inbetriebnahme der European Spallation Source ERIC (s. Tabelle in Anhang B2);
- Eine Beteiligung an den zusätzlichen Baukosten für die European Spallation Source ERIC (32 Mio. CHF für 2021−2024) und ITER/Fusion for Energy (110 Mio. CHF für 2021−2024);
- Eine Beteiligung als Gründungsmitglied an der Errichtung der Infrastruktur CTAO ERIC (10 Mio. CHF für 2021−2024);
- Einen Beitritt zur Infrastruktur SKA (9 Mio. CHF für 2021−2024).

Die entsprechenden Beträge müssen, vorbehältlich der Beschlüsse des Bundesrats, in der BFI-Botschaft 2021−2024 oder der Botschaft zur Finanzierung der Schweizer Beteiligung an den EU-Forschungsrahmenprogrammen beantragt werden. Die Infrastrukturen CTA und SKA gehören zu den in der Roadmap 2015 erfassten vier Infrastrukturen dieser Kategorie, die 2017−2020 spezifisch geprüft werden mussten.

Die Prüfung der anderen beiden Infrastrukturen, ELI und LBNF-DUNE, hat für 2021−2024 keinen Finanzierungsbedarf aus dem BFI-Budget ergeben. Die Prüfung der beiden Infrastrukturen wird jedoch in der Periode 2021−2024 im Hinblick auf die BFI-Botschaft 2025−2028 weiterverfolgt, parallel zu den in Kapitel 7.1 beschriebenen Infrastrukturen

Eine Tabelle mit den Kostendetails ist in Anhang B2 zu finden.

8. Fazit und Ausblick

Die in dieser Roadmap 2019 zur Umsetzung vorgeschlagenen FIS spiegeln den Planungsstand per Ende März 2019.

Das WBF (SBFI) ist dafür verantwortlich, die in der Roadmap 2019 enthaltenen Mehrjahresplanungen der zuständigen Förderorgane zu berücksichtigen und dem Bundesrat mit der BFI-Botschaft 2021−2024 – im Rahmen der verfügbaren BFI-Mittel – seine allfälligen Umsetzungsvorschläge zu unterbreiten.

Als Planungsinstrument liefert die Roadmap einen Überblick über neu geplante Forschungsinfrastrukturen und auch aktuelle Informationen zur Umsetzung von Vorhaben, die in der Roadmap 2015 ausgewählt wurden. Zudem dient sie als Basis für die notwendige Abstimmung der nationalen Planung im FIS-Bereich mit den entsprechenden Planungen auf internationaler und europäischer Ebene gemäss der ESFRI-Roadmap.

Diese Roadmap enthält jedoch keine Finanzierungsbeschlüsse über die Höhe oder die Verteilung allfälliger Bundesmittel auf Förderkredite der BFI-Botschaft 2021−2024. Im Bereich der kantonalen Hochschulen unterstützt der Bund indirekt Infrastrukturen nach dem Subsidiaritätsprinzip gemäss dem Hochschulförderungs- und -koordinationsgesetz (HFKG). Im ETH-Bereich sind der ETH-Rat, die beiden Hochschulen ETHZ und EPFL sowie die vier Forschungsanstalten im Rahmen des ETH-Gesetzes und der strategischen Ziele des Bundesrates für den ETH-Bereich für die Realisierung ihrer Forschungsinfrastrukturen zuständig. Bei den Forschungsinfrastrukturen, die Gegenstand der Mehrjahresplanung der Forschungsorgane sind, hängen Umsetzung und Finanzierung der Vorhaben vom Finanzierungsbeitrag des Bundes an den SNF und die Akademien ab. Der Bund ist für die Beteiligung der Schweiz an internationalen (europäischen) Forschungsinfrastrukturen zuständig.

Die eingesetzten Mittel werden – entsprechend dem Zahlungsrahmen des ETH-Bereichs, dem Kredit gemäss HFKG, dem Kredit für die Forschungsorgane und dem Kredit für die internationale Zusammenarbeit – vom Parlament im Kontext der BFI-Botschaft 2021−2024 beschlossen.

Im Hinblick auf die nächste Roadmap im Jahr 2023 wird das SBFI zusammen mit den Stakeholdern das Verfahren überprüfen und entsprechend der Ergebnisse gegebenenfalls anpassen.

9. Glossar

Abkürzung	Bedeutung
BR	Bundesrat
BFI	Bildung, Forschung und Innovation
Eawag	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (ETH-Bereich)
Empa	Eidgenössische Materialprüfungs- und Forschungsanstalt (ETH-Bereich)
EPFL	École polytechnique fédérale de Lausanne
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
ETH	Eidgenössische Technische Hochschule
ETHZ	Eidgenössische Technische Hochschule Zürich
FIFG	Bundesgesetz über die Förderung der Forschung und der Innovation (SR 420.1)
FIS	Forschungsinfrastruktur
HFKG	Hochschulförderungs- und -koordinationsgesetz (SR 414.20)
MJP	Mehrjahresprogramm
PGB	Projektgebundene Beiträge
PSI	Paul Scherrer Institut (ETH-Bereich)
SAGW	Schweizerische Akademie der Geistes- und Sozialwissenschaften
SAMW	Schweizerische Akademie der medizinischen Wissenschaften
SBFI	Staatssekretariat für Bildung, Forschung und Innovation
SCNAT	Akademie der Naturwissenschaften Schweiz
SHK	Schweizerische Hochschulkonferenz (gemäss HFKG)
SNF	Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung
SWR	Schweizerischer Wissenschaftsrat
swissuniversities	Rektorenkonferenz der Hochschulen (gemäss HFKG)
WBF	Eidgenössisches Departement für Wirtschaft, Bildung und Forschung
WSL	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (ETH-Bereich)

Schweizer Roadmap für Forschungsinfrastrukturen 2019

Anhang A

Anhang A1: Neu geplante nationale FIS der Roadmap 2019 (oder substanzielle Upgrades)

Wichtige Anmerkungen:

1) **Die hier aufgeführten Finanzzahlen sind Planzahlen der Hochschulen / Verantwortlichen der Infrastrukturen.**
2) **Die hier aufgeführten Finanzzahlen für die BFI-Perioden 2021−2024 und 2025−2028 sind Planzahlen. Sie dienen einer groben Abschätzung der voraussichtlich anfallenden Kosten und deren Verteilung.**
3) **Letzte Aktualisierung der Informationen: Januar 2019**

Anhang A1: Neu geplante nationale FIS der Roadmap 2019 (oder substanzielle Upgrades)

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

Category: e-Infrastructure

Host institution(s): ETH Zurich

Main funding sources: ETH Board, ETH Zurich

Description / Development prospects

a. National level

Overview

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

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

Detailed description

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

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

The buildup of the successor to Piz Daint began in 2018 with site preparation. A test and development system will be installed in late 2019 and the actual system will start to be brought onsite in 2020. A rigorous evaluation of node architectures with all processors options is being carried out since 2018 and will continue until 2020. In late 2021, full scale-out of the system will be started and is expected to complete in 2022. Operations will begin in 2023 and run through 2028 at least. An upgrade of the compute nodes is anticipated for 2026.

b. International level

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

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

c. Development prospects

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

d. Costs (in CHF)

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

Development Phases	Years
Design	2018-2020
Preparation	2020-2021
Implementation	2021-2022
Operation	2023-2028+

2. Swiss Light Source SLS 2.0[40]

Category: Instrument

Host institution(s): PSI

Main funding sources: ETH Board, PSI

Description / Development prospects

a. National level

Overview

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

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

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

Detailed description

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

- In x-ray ptychography (a microscopic technique pioneered at SLS) it will be possible to collect images in seconds or minutes instead of hours.
- SLS is among the leaders in x-ray tomography, resulting in benefits to clinical medicine as well as fundamental and applied sciences. SLS 2.0 will generate more brilliant as well as harder x-ray beams with a larger penetrating power, allowing static and time-dependent tomography for a much larger range of systems.
- The smaller beam produced by SLS 2.0 will enable analysis of sub-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 the small devices of contemporary and future technological importance.

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

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

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

3. Catalysis Hub (CAT+)

Category: Technical Infrastructure

Host institution(s): ETH Zurich and EPFL

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

Efficient catalytic technologies are a recognized tool to address the needs of sustainable chemical production and energy storage/conversion. In this respect, top-level research and teaching institutions worldwide are significantly investing in dedicated catalysis research centers 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 provides the platform to raise talents and to stay competitive on a global level. Cat+ is open to Swiss academics and industries. It will also welcome international participations and seeks the exchange with other leading centers for advancing the state-of-the-art in catalysis research.

c. Development prospects

The key aim for the initiation years of Cat+ 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 of the ETH Domain. This unifying approach enables the center to react efficiently to tackle the challenges of future catalysis research and sustainable development. Beyond 2025, we expect that the majority of the Cat+ users will be able to fund their use of the infrastructure by a pay-per-use basis. Additionally, we expect in the long-term significant industry interest once the full potential of Cat+ is

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

d. Costs (in CHF)

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

Development Phases	Years
Design	2019-2020
Preparation	2020-2021
Implementation	2020-2022
Operation	2023-onward

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

Category: Instrument

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

Main funding sources: Cantonal Funding, ETHZ

Description / Development prospects

a. National level

Overview

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

Detailed description

The 1.2 GHz NMR instrument will provide a major increase in experimental sensitivity and resolution for the analysis of biomolecules. The magnet uses a novel break-through 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. Those are studied by the applicant groups and many other Swiss research groups. Applications will encompass studies of structure, function, dynamics and folding of biomacromolecules including, but not limited to integral membrane proteins, membrane protein complexes, pathogenic bacterial systems, large molecular machines, protein–RNA complexes, and medically relevant drug targets. Further applications are the development of drugs and of new high-resolution NMR methods. The generated data will provide key insights into fundamental biological mechanisms such as protein biogenesis, signaling, allosteric regulation, catalysis, RNA regulation and splicing, as well as epigenetics in normal and disease-causing biomolecular systems.

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

Currently, NMR centers in Switzerland exist 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 centers are located e.g. in Berlin, Frankfurt, Göttingen, Munich, Florence, Grenoble, Lyon, Gif-sur-Yvette, Lille, Utrecht, Nijmegen, Oxford, Cambridge, Birmingham, Gothenburg, Kopenhagen, Brno and Ljubljana.

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

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

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

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

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

c. Development prospects

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

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

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

d. Costs (in CHF)

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

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

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

Category: Integrated Research Infrastructure

Host institution(s): University of Zurich

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

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

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

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

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

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

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

6. Center of Structural Electron Microscopy (COSEM)

Category: Instrument

Host institution(s): University of Zurich

Main funding sources: University of Zurich, Foundations

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

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

c. Development prospects

Despite the recent breakthroughs, cryo-EM remains a dynamic and rapidly developing field. Direct electron detectors were introduced only 6 years ago and are still under development. Similarly, sample preparation and image analysis are likely to be developed further in the coming 5-10 years. Whereas the structure determination of single particle analysis is now routine and accessible to a large user community, a similar development for cryo-electron tomography has still to occur. Therefore, a major aim of COSEM will be to maintain its high-end standards and to drive new technological developments. For that purpose, the members of the ZMB including the employed staff scientist and the scientific advisory committee will routinely attend technical conferences and interact with the relevant companies. It is foreseen that next generation detectors, phase plates and image processing software will become available over the projected duration of the center. COSEM and the ZMB are committed to follow these developments and to maintain the center as a facility offering state-of-the-art services to researchers in Switzerland.

d. Costs (in CHF)

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

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

7. Linguistic Research Infrastructure (LiRI)

Category: Information and services infrastructure

Host institution(s): University of Zurich

Main funding sources: University of Zurich

Description / Development prospects

a. National level

Overview

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

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

Detailed description

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

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

LiRI is conceived in its full form as a national platform for linguistic data storage/processing/science, uniting if possible as many linguistic data resources of all kinds (text, audio, video, EEG etc.) in one data center. Many linguistic research units from all over the country as well as academic institutions and cooperation partners as the academy (SAGW). LiRI will thus considerably strengthen national cooperations and boost interuniversity dialogue and projects.

b. International level

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

structure all future linguistic data, including those coming from our external cooperation partners and make them accessible long-term through widely used repositories.

c. Development prospects

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

d. Costs (in CHF)

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

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

Anhang A2: Aktualisierte nationale FIS der Roadmap 2015

Vorbemerkung

Die in der Roadmap 2015 zur Umsetzung empfohlenen Forschungsinfrastrukturen wurden gemäss ihrem Entwicklungsstand zwischen Ende 2018 und Anfang 2019 aktualisiert. Die entsprechenden Daten, die bei den Verantwortlichen der Infrastrukturen erhoben wurden, werden im vorliegenden Anhang A2 präsentiert. Die FIS werden nach ihrem wissenschaftlichen Bereich aufgeführt:

- Geistes- und Sozialwissenschaften
  - Swiss Art Research Infrastructure (SARI)
  - Data and Service Center for the Humanities (DaSCH), vormals Swiss Digital Humanities Center (SDHC)
  - Mixed-Reality Lab for Behavioral Research (MIRAL)

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

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

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

Es ist darauf hinzuweisen, dass die Daten zu FIS aus der Roadmap 2015, die für die Roadmap 2019 ein substanzielles Upgrade («major upgrade») erfahren haben, nur in Anhang A1 enthalten sind. Dabei handelt es sich um die Vorhaben High-Performance Computing and Networking (HPCN-24), Swiss Light Source SLS 2.0, Airborne Research Facility for the Earth System (ARES) und Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR).

Nicht alle hier beschriebenen Infrastrukturen erfüllen das neue Kriterium der Roadmap 2019 zum Mindestbudget von fünf Millionen Franken, da es sich um aktualisierte Daten zu den Infrastrukturen der Roadmap 2015 handelt. Die FIS der Roadmap 2015 mussten jedoch die folgenden Kriterien erfüllen:

- *einen wesentlichen Beitrag zur Entwicklung eines Wissens- bzw. Forschungsgebietes leisten (wissenschaftlicher Mehrwert);*
- *von den Forschenden in der Schweiz intensiv genutzt werden (nationale Bedeutung);*
- *grundsätzlich nationalen und internationalen Forschergemeinschaften offenstehen (freier Zugang);*
- *an einem einzigen Standort situiert oder in einem Netzwerk mit mehreren Standorten mit zentraler Managementstruktur organisiert sein.*

Wichtige Anmerkungen:

1) **Die hier aufgeführten Finanzzahlen sind Planzahlen der Hochschulen / Verantwortlichen der Infrastrukturen.**
2) **Die hier aufgeführten Finanzzahlen für die BFI-Perioden 2021−2024 und 2025−2028 sind Planzahlen. Sie dienen einer groben Abschätzung der voraussichtlich anfallenden Kosten und deren Verteilung.**
3) **Letzte Aktualisierung der Informationen: Oktober 2018−Februar 2019**

Swiss Art Research Infrastructure (SARI)

Category: Information and Service Infrastructures

Host institution(s): University of Zurich

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

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

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

c. Development prospects

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

d. Costs (in CHF)

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

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

Data and Service Center for the Humanities (DaSCH)

Category: Information and service infrastructures

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

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

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

innovative technology that is very promising for the future and shows great potential. It is open to international cooperation by using accepted standards (IIIF, LOD, RDF, REST, JSON-LD etc.) and close collaborations and exchanges with similar national and international institutions have been established.

c. Development prospects

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

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

d. Costs (in CHF)

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

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

Mixed-Reality Lab for Behavioral Research (MIRAL)

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

Host institution(s): University of St. Gallen

Main funding sources: University of St. Gallen

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

The behavioral researchers at the University of St. Gallen are extensively collaborating with other Swiss, European, and North-American schools, which continuously profits from the RI and strengthen the academic position of Swiss behavioral research across different disciplines both nationally and internationally.

c. Development prospects

The MIRAL will be 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 behavioral lab. This lab now includes common laboratory infrastructure to address research questions in the real, physical and the virtual, online world (e.g., infrastructure, PCs, shopping aisle). In the second stage (2018-2021), MIRAL will be improving integration of VR environments and biometrical measurement, extending its biometrical measurement capabilities (EEG, ECG) and developing lab team's capabilities for enhanced support in terms of scientific rigor of experiments.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 1.952 Mio.	Higher Education Institution 1.450 Mio	Higher Education Institution 1.550 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 0.612 Mio.	Third parties 0	Third parties 0
Total budget 2.564Mio	**Total 1.450 Mio**	**Total 1.550 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments N/A	Investments 0.350 Mio	Investments 0.450 Mio
Operating costs N/A	Operating costs 0.950 Mio	Operating costs 0.950 Mio
Other costs N/A	Other costs 0.150 Mio	Other costs 0.150 Mio
Total costs 2.564 Mio	**Total 1.450 Mio**	**Total 1.550 Mio**

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

Swiss National Ion-microbe Platform (SwissNIP)

Category: Technical Infrastructure

Host institution(s): University of Lausanne

Main funding sources: University of Lausanne / SNF

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

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

c. Development prospects

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

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

d. Costs (in CHF)

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

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

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

Category: Instruments

Host institution(s): SUPSI

Main funding sources: SUPSI, Competitive Funds

Description / Development prospects

a. National level

Overview

The Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials is a centre specialised in the mechanical characterization of materials in dynamics able to measure accurately 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 temperature.

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

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

Detailed description

In the laboratory is possible to perform tests in tension, compression, shear, torsion and bending for different materials at high strain-rates and in a large field of temperature (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 aero-space.
- 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 the materials in a wide range of strain-rate tests (1÷10^{5} s^{-1}). These apparatus can be long from some meters to 15m, and have different bar diameters, needed to test for example:

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

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

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 the role as reference point for industries and research centre as well as international universities. The development of training and mentoring of Swiss and international young researchers will create the opportunity to do cutting-edge studies and collaborate with other world-class facilities and experts. The Laboratory will act as a node 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 inserted in the International network of laboratories of dynamic of materials (DYMAT).

c. Development prospects

Dynamic behaviour of materials represents an ever expanding area of broad interest to the scientific community and industry. Understanding the dynamic response of materials improves design and safety of products and structures by means of calibration and validation of numerical models.
The Swiss Laboratory for Advanced Studies on the dynamic behaviour of materials is strongly specialized in the experimental issues, analysing the material behaviour in mono-axial, bi-axial and tri-axial loading conditions in combination with additional variables as temperature and other severe conditions (i.e. irradiation).
To reach the objective of being a reference laboratory on the mentioned topics, it is necessary to constantly improve the set of devices through the design of new machines and the construction of complementary set-ups. New machines are essential to respond to the needs of research and development in the field of dynamic behaviour of materials have been included. In order to cover a wide area of applications it is necessary to study the torsion behaviour as well as the combination of tension/torsion. Traditional Split Hopkinson Pressure Bar (SHPB) can easily respond to the dynamic indentation purposes (two set-ups have been scheduled). Many industrial applications involve biaxial stress conditions, consequently dynamic biaxial behaviour studies are required. The new RI must cover these issues by means of the developing of biaxial apparatus at medium and high strain rate (biaxial MHB). Moreover the new TriHB has to be completed as well as the Collision test apparatus have to be built. Finally, the system of MHB in bending is required to study the fracture mechanics parameters in a wide range of strain rate.

d. Costs (in CHF)

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

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

Next Evolution in Sustainable Building Technologies (NEST)

Category: Technical Infrastructure

Host institution(s): Empa, Eawag

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

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

b. International level

NEST is also gaining international recognition in the Living Lab scene thanks to the unique features it offers. To the best of our knowledge, there exists no comparable platform with a similar approach which is not user but research dominated. The number of international delegations from the public sector and from industry is increasing. Numerous large international companies have recently joined NEST as partners or are planning to do so in the near future. Collaborations with high ranked institutions such as Harvard University or Imperial College have been established.

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

c. Development prospects

It can be expected that within 2-3 years the available space for units will be used up and then the replacement of units from the first generation with new units will take place. The topic of the units is not defined yet, it is planned to keep the open innovation approach and to react flexible on the interest of

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

d. Costs (in CHF)

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

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

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

Category: MINT

Host institution(s): university of Zurich

Main funding sources: SNF, ERC and international partners

Description / Development prospects

a. National level

Overview

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

Detailed description

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

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

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

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

Category: Instruments

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

Main funding sources: ETH Domain

Description / Development prospects

a. National level

Overview

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

Detailed description

ATHOS will add a second electron beam transport system to SwissFEL that will feed a variable-gap undulator line for producing soft x-ray laser beams. ATHOS will operate simultaneously with ARAMIS (energy range 1.8 keV – 12.4 keV) and will be optimized for producing radiation in the 250 - 1900 eV x-ray regime, with full polarization control. This energy region covers absorption edges for the light elements oxygen, carbon and nitrogen that play an important role in many chemical and biological processes, as well as those of the transition metals manganese, iron, cobalt, nickel, and copper, which are prominent components in classical and quantum devices. Also the absorption edge of silicon can be reached with ATHOS to cover the science related to semiconductor research.
A key feature of the ATHOS facility is the use of small magnetic chicanes between each undulator in order to manipulate the electron bunch during the lasing process and thus offering new capabilities beyond those implemented at operating facilities:
- Full control of soft x-ray polarization (circular, linear, elliptical). Such a capability is extremely useful for the study of magnetic materials.
- Sub-femtosecond pulses with enough energy (above 100 μJ) very important for atomic, molecular and optical physics, as well as for non-linear x-ray optics.
- Parallel operation with ARAMIS at full 100 Hz rate. With a dedicated accelerating module in the ATHOS branch the electron bunch and photon beams in ATHOS can be rapidly tuned for its full photon energy range without disturbing ARAMIS operation.
- Simultaneous production of two-color pulses with adjustable delay by splitting the 16 undulators in two sections separated by a delay chicane. Such pulses will be particularly convenient for performing stimulated resonant inelastic x-ray scattering (RIXS).

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

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

b. International level

The impact of XFELs, the new generation of x-ray radiation source, has been demonstrated so far by the first two XFELs in operation: LCLS at Stanford (operating since 2009), SACLA in Japan (operating since 2011) and European XFEL in Hamburg (operating since 2017). In 2017, first successful experiments were performed with SwissFEL, contributing to science development. Analogous to the other analytical research facilities of PSI, SwissFEL is open to the international research community. SwissFEL will provide a total of 5000 hours beamtime per year and per FEL beamline (ATHOS and ARAMIS) at different experimental stations.

c. Development prospects

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

d. Costs (in CHF)

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

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

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

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

Host institution(s): University of Geneva

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

Another task of the CDCI is to serve data of current and past missions to the widest possible com-munity with as much added value as possible. Most missions retain their scientific values many decades after the end of the mission. Without dedicated effort, this knowledge can disappear in little more than a few years.

Furthermore, software ages, and becomes more and more difficult to install on new hardware. The CDCI keeps alive the data of the missions it is involved in. This means not only maintaining the data archives and software, but also providing web services allowing to run simplified and yet powerful and fully validated analyses. For this purpose, the CDCI shall use modern software technologies, deploying containers on a cloud. The first development of the CDCI, the INTEGRAL Online Data Analysis, has been released to the public by the end of 2018.

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

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

[44] Planned proposal under article 15 RIPA for the next period. Numbers can change as the proposal not submitted yet. Funding decision in fall/w inter 2024.

Center for biomedical research in space

Category: Instruments and service infrastructure

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

Main funding sources: Third party funding

Description / Development prospects

a. National level

Overview

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

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

Detailed description

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

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

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

b. International level

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

c. Development prospects

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

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

An additional goal of the CBRS is to implement new features to the RPMs like enabling to take microscopy pictures while operating. This broadens the operative range of the RPMs substantially, which increases the attractiveness of this instrument even more. Therefore, technological development will be fostered to incorporate more and more analytical tools into the RPM. For doing so, cooperations will be established with leading Swiss research groups in technology at HSLU and elsewhere as well as with the industry. There is no doubt that such technological development will end in space or in terrestrial applications.

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

d. Costs (in CHF)

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

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

Swiss Plasma Center (SPC)

Category: Instruments

Host institution(s): Ecole polytechnique fédérale de Lausanne

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

Theory of Plasmas

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

Basic Plasma Physics (experimental, TORPEX)

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

Hot Plasmas Physics (fusion, tokamak, TCV)

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

International collaborations

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

Superconductivity for Fusion

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

Plasma Applications

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

b. International level

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

c. Development prospects

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

TCV tokamak systems and related spin-offs

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

o a new divertor chamber, in the process of being inserted at the periphery of the plasma to achieve reactor relevant conditions and pioneer solutions to the crucial problem of plasma exhaust;

o two dual frequency gyrotrons for improving the plasma performance;

o a second 1 MW NBH system with high-energy capabilities, to study burning plasma regimes;

o improvements in diagnostic capabilities, with extended 2D coverage and potential for real time control.

Basic plasma physics and applications

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

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

d. Costs (in CHF)

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

Development Phases	Years
Design	2015-2018
Preparation	2017-2019
Implementation	2018-2020
Operation	2019 and beyond

National Research Centre for Animal Cognition

Category: Infrastructure

Host institution(s): University of Neuchatel

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

b. International level

In the US, the Yerkes Primate Center in Atlanta and the regional primate centre in Bastrop regularly carry out cognition research. Both Lincolm Park Zoo and the National Zoo in Washington have facilities where the public can observe behavioural experiments with great apes. Japan has also invested heavily in animal cognition with a Primate Research Institute housing approximately 500 primates. In Europe,

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

c. Development prospects

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

d. Costs (in CHF)

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

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

Swiss Research Network of Clinical Pediatric Hubs (SwissPedNet)

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

Host institution(s): Mainly hospitals[45].

Main funding sources: Host institutions

Description / Development prospects

a. National level

Overview

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

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 research in children.

Detailed description

While being dedicated to children, 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. To allow for resource saving synergies, the central office of the SwissPedNet is located within the SCTO Executive Office.

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

b. International level

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

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

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

SwissPedNet is member of the consortium of the IMI2 funded project c4c/conect4children: the collaborative network for European clinical trials for children is a project for the development, implementation and evaluation of robust, sustainable and integrated pan-European network trial delivery. Since its inception SwissPedPha has been recognized internationally and this has resulted in collabo-rations with several European countries such as Belgium, Norway, Germany, and the Netherlands. Until now these collaborations have focused on the unique expertise of SwissPedPha in advanced pharmacometric modeling & simulation as well as developmental pharmacology. The existing collaborations have resulted in multiple joint publications, training of international master and PhD students in Switzerland. The opportunity provided by the funding of SwissPedPha has resulted in a clear visibility and has made Switzerland one of the top three countries in Europe in the discipline of pediatric pharmacology and pharmacometrics. The other two countries are France and the Netherlands.

c. Development prospects

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

d. Costs (in CHF)

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

Development Phases	Years
Design	2011
Preparation	2012
Implementation	2012-2016
Operation	2017ff

[46] SCTO: Swiss Clinical Trial Organisation supported by SERI (art.15 of the Federal Act on the Promotion of Research and Innovation (RIPA). SCTO received CHF 14 mio for 2017-2020 (art. 15, RIPA) and allocated CHF 3.124 mio to SwissPedNet.
[47] SCTO will apply for CHF 21.4 mio for the 2021-2024 (art. 15, RIPA) and plan to allocate CHF 5.28 mio to SwissPedNet. Numbers can change as the proposal not submitted yet.
[48] SCTO plan to allocate CHF 5.438 mio to SwissPedNet from its yet unknown art. 15 (RIPA) contribution in 2025-2028 unknown).

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

Category: Technology Competence Center

Host institution(s): Balgrist Campus AG

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

Description / Development prospects

a. National level

Overview

Balgrist Campus is an initiative of the ResOrtho Foundation dedicated to the creation of an optimal infrastructure for musculoskeletal research and education and "Schweizerischer Verein Balgrist", a non for profit organization with the mission to improve the care of the musculoskeletal patient. Balgrist Campus has established a Swiss platform for nationwide research, development, and translation in the field of musculoskeletal science and medicine to the benefit of musculoskeletal patients of today and tomorrow, closing the loop between understanding of musculoskeletal disorders and treatment. The core facilities of this musculoskeletal research and development center include:

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

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

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

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

Detailed description

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

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

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

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

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

In 2017 the Balgrist Beteiligungs-AG was established at Balgrist Campus to support innovative development projects and their transition to startup companies. Within the first two years, 5 startups have been supported and several patent applications submitted. The collaboration with established medtech companies already led to a sale of one of the projects and two licensing arrangements.

b. International level

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

c. Development prospects

In early 2019, the Children's Hospital of Zurich has relocated research groups to the Campus, intensifying and enlarging collaboration between the university medical institutions. The research infrastructures at the Balgrist Campus have already enabled affiliated investigators and their national and international collaborators to apply for research project funding at the Swiss National Science foundation, the EUH2020 program, and the U.S. National Institutes of Health.

The SCMB at Balgrist Campus is participating in a SNSF application which aims to establish a multi-center biobank IT infrastructure. This direct IT connection between biobanks is focusing on the secure handling of sensitive medical data in order to protect the privacy and confidentiality.

d. Costs (in CHF)

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

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

[49] Planned proposal for funding according to article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Funding decision by EAER in fall/winter 2020.

Neuchâtel Platform for Analytical Chemistry (NPAC)

Category: Technical infrastructure

Host institution(s): University of Neuchâtel

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

b. International level

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

c. Development prospects

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

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

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

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

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

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

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

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

d. Costs (in CHF)

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

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

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

Category: Information and service infrastructures

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

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)

Description / Development prospects

a. National level

Overview

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

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

Detailed description

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

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

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

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

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

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

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

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

Category: Distributed

Host institution(s): SWITCH Foundation

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

Description / Development prospects

a. National level

Overview

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

Detailed description

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

SWITCHengines: provides compute 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 contribute its cloud infrastructure for supporting the research community - in balance with e-Science- and IT-teams of universities. Its components are located in Zurich and in Lausanne.

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

b. International level

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

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

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

c. Development prospects

SWITCHlan has laid the foundations for the development until 2020 and beyond. Therefore within period 2020-2024, the network will undergo incremental improvements in specific locations and we expect individual institutions to upgrade their connectivity to higher bandwidths. It should also be noted that the benefits of the upgrade consist not only of increased bandwidth and improved resilience, but also in new functionality and flexibility. On the international level, SWITCH will continue its participation in the series of GÉANT projects within the framework Horizon2020, currently planning to contribute to GN4-3. SWITCH-CERT is continuously extending and improving its detection and response capabilities as well as the accuracy of the Swiss threat landscape. In addition, SWITCH-CERT works with the community on development of further managed security services.
SWITCHengines is being run as production quality cloud infrastructure. The supported functionality is being continuously extended according to the users's needs. Most recent new services comprise a dedicated administrative user interface custom-tailored to the needs of universities and the support for virtual private cloud (L2 connectivity between Campus and Engines networks) and container technology. The service infrastructure is being expanded according to the growth of its usage.
SWITCHaai: The development concentrates on two avenues: First and foremost it coordinates and supports the institutions to adopt the edu-ID. Secondly, it enhances the supported functionality of edu-ID in various ways beyond what is possible with SWITCHaai today. This is a strong motivation for the institutions to adopt the edu-ID.
Remark to the costs: The cost for the SWITCHlan and of the SWITCHaai / SWITCH edu-ID infrastructure are not available as the participating institutions do not publish their costs on their side. The following figures contain the central part of SWITCH only. For this infrastructure, which all provide running services, full cost are covered by the institutions in higher education and research (universities, universities of applied sciences, universities of teacher education). Some subsidies come from the EC via Horizon2020 and the next framework program. The investments are written of and therefore included in the operating cost.

d. Costs (in CHF)

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

Development Phases	Years
Design	Continuous development
Preparation	N/A
Implementation	N/A
Operation	2017 – 2028 ff

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

Swiss Data Science Center (SDSC)

Category: Information and Service Infrastructure

Host institution(s): EPFL and ETH Zurich

Main funding sources: ETH Domain

Description / Development prospects

a. National level

Overview

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

Detailed description

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

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

RENKU offers:

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

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

b. International level

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

c. Development prospects

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

d. Costs (in CHF)

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

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

Schweizer Roadmap für Forschungsinfrastrukturen 2019

Anhang B

Anhang B1: Zu prüfende Beteiligungen an internationalen Forschungsinfrastrukturen

Vorbemerkung

Infrastrukturen, an denen Schweizer Institutionen bereits beteiligt sind:

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

Infrastrukturen, an denen Schweizer Institutionen interessiert sind:

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

Wichtige Anmerkungen:

1) **Die hier aufgeführten Finanzzahlen sind Planzahlen, die von den Hochschulen / Verantwortlichen der Infrastrukturen geliefert wurden.**
2) **Die hier aufgeführten Finanzzahlen für die BFI-Perioden 2021−2024 und 2025−2028 sind Planzahlen. Sie dienen einer groben Abschätzung der voraussichtlich anfallenden Kosten und deren Verteilung.**
3) **Letzte Aktualisierung der Informationen: Januar 2019**

European Plate Observing System ERIC (EPOS)

Legal form: *ERIC*

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

Funding in Switzerland:

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

Description

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

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

National relevance

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

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

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

[54] The participation fees from 2021 onward will be a part of the ERI dispatch 2021-2024. For 2019/2020 the participation fees are covered by ETH Zürich.

European Clinical Research Infrastructure Network ERIC (ECRIN)

Legal form: *ERIC*

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

Funding in Switzerland:

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

Description

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

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

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

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

National relevance

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

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

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

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

[56] The participation fees from 2021 onward will be a part of the ERI dispatch 2021-2024.

Integrated Carbon Observation System ERIC (ICOS)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

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

Description

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

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

National relevance

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

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

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

Biobanking and Molecular Resources Research Infrastructure ERIC (BBMRI)

Legal form: *ERIC*

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

Funding in Switzerland:

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

Description

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

BBMRI-ERIC is engaging with numerous stakeholders: European Community, researchers, institutions, patient organisations, standardisation organisations, other research infrastructures, health and research ministries, biobanking intiatives and societies. 19 countries are participating as members (Austria, Belgium, Czech Republic, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Malta, the Netherlands, Nor-way, Sweden, and the United Kingdom), 4 as observers (Switzerland, Cyprus, Poland and Turkey) and one international organisation (International Agency for Research on Cancer (IARC)/WHO).

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

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

National relevance

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

[59] The total includes the participation fees.

[60] The participation fees are planned to be paid by SNSF through the budget allocated to SBP.

Consortium of European Social Science Data Archives ERIC (CESSDA)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

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

Description

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

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

National relevance

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

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

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

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

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

European Social Survey ERIC (ESSurvey)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

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

Description

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

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

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

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

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

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

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

Legal form: *ERIC*

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

Funding in Switzerland:

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

Description

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

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

National relevance

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

Thanks to the continuous financial support of the Swiss National Science Foundation, Switzerland has participated in each round of SHARE since its beginning in 2004 (Switzerland has an observer status in SHARE ERIC). This has contributed to the consistent provision of data of very high quality to researchers. The uninterrupted, high quality and timely prepared Swiss datasets make it possible that Switzerland's data are included in a very large proportion of publications using SHARE data. The Swiss data are not only used by Swiss researchers, but also by researchers working abroad. Indeed, a large majority of the publications involve comparative analyses and include the Swiss data as well. In addition, supported by the easy access to the data and the popularity of the survey, the SHARE data are also a reference for international contextualization and very often used in publications for this purpose, like the OECD statistics or the WHO, helping Switzerland being present on the international scene. In Switzerland, the SHARE data are also a reference for institutes such Obsan or statistical offices, which provide a statistical support for the Confederation, the cantons and other institutions.

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

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

Legal form: *ERIC*

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

Funding in Switzerland:

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

Description

DARIAH (https://www.dariah.eu/) is an acronym for Digital Research Infrastructure for the Arts and Humanities. It serves as pan-European co-operation of research infrastructures for humanists working with computer based methods. It promotes digital research as well as the teaching of digital research methods. Since 15th August 2014 DARIAH has been organized as a European Research Infrastructure Consortium (ERIC). For the time being, 17 countries are full members of DARIAH; they constitute the General Assembly. Switzerland is currently not member of the ERIC DARIAH, but nine academic institutions are Cooperating Partners of DARIAH. In order to coordinate the DARIAH-relevant activities in Switzerland in an efficient way, the Universities of Basel, Bern, Geneva, Lausanne, Neuchâtel, Zürich, the EPFL and the academy SAHSS signed on 30 October 2018 the Consortium DARIAH-CH. The purposes of the Consortium are to prepare the national infrastructure of DARIAH-CH from 2021 onwards by establishing and financing a Swiss National Point of Contact.

National relevance

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

In this situation, the Swiss humanities research landscape needs collaborative international partnership. DARIAH forms the most powerful network of research infrastructures and humanists in Europe one can join to get support for achieving the above-mentioned challenges. In general, for Switzerland as non-EU-member state, the cooperation in European programs can be challenging. DARIAH offers a possibility to get involved on a national level with a European research community without the disadvantage of a special status or restrictions. The list below shows the advantages for members:

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

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

Partnership for Advanced Computing in Europe (PRACE)

Legal form: *Association*

Main funding sources: *Member states*

Funding in Switzerland:

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

Description

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

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

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

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

National relevance

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

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

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

[68] The participation fees are paid by ETHZ.

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

Legal form: *ERIC*

Main funding sources: *Member states*

Funding in Switzerland:

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

Description

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

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

National relevance

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

This situation makes the Swiss participation to the ECCSEL-ERIC both extremely effective and useful. Moreover, it makes the yearly investments of the Swiss Federal Offices (first of all SFOE and swisstopo) on national and international programs on CCS and on research infrastructure that serves the CCS scientific community (the underground laboratories mentioned above) even more productive.

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

[69] The total includes the participation fees and is contributed mainly by institutions of the ETH Domain, namely ETH Zurich, EPF Lausanne and Paul Scherrer Institute, by the PIs involved, as well as by swisstopo (for underground laboratory infrastructure).
[70] The participation fees are paid by SERI from 2021 (till 2020 paid by ETHZ and other Swiss partner).

Aerosol, Clouds, and Trace Gases (ACTRIS)

Legal form: *ERIC (foreseen)*

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

Funding in Switzerland:

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

Description

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

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

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

National relevance

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

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

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

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

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

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

Funding in Switzerland:

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

Description

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

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

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

National relevance

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

[73] The total includes the participation fees and is contributed mainly by the Swiss Federal Research Institute WSL.
[74] The participation fees are paid by WSL, Uni Basel (SLU), Uni Basel (ALPFOR), ETHZ (Grassland Sciences).

Extreme Light Infrastructure (ELI)

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

The mode of participation of Switzerland in ELI isn't yet settled. In a first phase, the ELI Host States could request a financial support from Switzerland in view of the ELI operation in the context of the Swiss contribution to the enlarged EU.

Description

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

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

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

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

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

National relevance

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

.

Anhang B2: Beteiligung an internationalen Forschungs-organisationen

Vorbemerkung

Die Schweiz ist im Rahmen multilateraler Abkommen Mitglied mehrerer internationaler Forschungsorganisationen. Die untenstehende Tabelle zeigt die Auswirkungen des geschätzten Finanzbedarfs für diese Kategorie von Infrastrukturen auf den Aufgabenbereich Bildung und Forschung in den von den BFI-Botschaften 2017−2020 und 2021−2024 abgedeckten Perioden.
Die Tabelle wurde vom SBFI im Februar 2018 erstellt, wobei für die Periode 2017−2020 die 2017 erfolgten Zahlungen und die für 2018−2020 geplanten Zahlungen gemäss den vom Parlament bewilligten Krediten berücksichtigt wurden. Für die Periode 2021−2024 bezieht sich die Schätzung des SBFI auf die Zahlungen, die die Schweiz angesichts bereits bestehender Verpflichtungen tätigen dürfte und die sich aus allenfalls in naher Zukunft eingegangenen Verpflichtungen ergeben könnten (die entsprechenden Zahlen sind in der Tabelle *kursiv und unterstrichen*). Zwischen Februar 2018 und dem Veröffentlichungsdatum dieser Roadmap ist keine Veränderung zu verzeichnen.

Rechtsgrundlagen der Finanzierung	**Internationale Forschungsorganisation (IFO)**	**2017−2020 (Mio. CHF, *geplant*)**	**2021−2024 (Mio. CHF, *geschätzt*)**
bestehende IFO *Botschaften Voranschlag / ESS / BFI 13−16*	CERN	181	189
	ESO	38	45.5
	EMBC/EMBL	24	26.5
	ESRF	17	18
	European XFEL	7.5	15.5 [1]
	European Spallation Source ERIC (ESS)	58.5	50 + *32* [2]
	ILL (2014−2018)	6.5	-
	Begleitmassnahmen	12	12
Total		**344.5**	**388.5**
neue IFO *Botschaften BFI 17−20 / CTA*	ILL (2019−2023) [3]	6.5	8.5
	CTA [4]	*2.5*	*10*
Total		344.5 + 9 = **353.5**	388.5 + 21 = **409.5**
neue IFO *BFI-Botschaft 21−24*	ILL (2024−2028) [5]		*2.5*
	SKA	-	*9*
	ELI [7]	-	*0* [6]
	LBNF-DUNE	-	*0* [6]
	Gesuche um Sondergesten des CERN	-	*0* [6]
Total		**353.5**	409.5 +9 = **418.5**
IFO «CH-EU» *Botschaften EU 14−20 / 21−27*	ITER/Fusion for Energy	78.5	*29* + *110* [8]
Auswirkungen auf den Aufgabenbereich Bildung und Forschung		353.5 + 78.5 = **432**	418.5 + 139 = **557.5**

[1] Ab 2023 werden die Beiträge der Schweiz an European XFEL anhand der – intensiven – Nutzung der Infrastruktur durch die Schweizer Forschenden in den vorhergehenden Jahren berechnet, was eine Erhöhung dieser Beiträge erwarten lässt.

[2] *Schätzung* der allfälligen Beiträge der Schweiz an die zusätzlichen Kosten in der Periode 2021−2024.

[3] Die Beteiligung der Schweiz an den IFO ist ausser beim ILL in der Regel zeitlich nicht begrenzt. Mit dem ILL schliesst die Schweiz Vereinbarungen für fünf Jahre ab, die nach dem Auslaufen aktiv verlängert werden müssen. Entsprechend kann jede Fünfjahres-Beteiligung am ILL (ILL 2014−2018, ILL 2019−2023, ILL 2024−2028) aus rechtlicher Sicht als Sonderbeteiligung an einer IFO betrachtet werden. Die Bedingungen der Schweizer Beteiligung an «ILL 2019−2023» wurden vom SBFI 2018 ausgehandelt.

[4] Aufgrund der Verspätungen beim Baubeginn des CTA sollen in der Periode 2017−2020 nur 2,5 Mio. CHF anstelle der gewährten 8 Mio. CHF gemäss den Beschlüssen aus der Beratung der BFI-Botschaft 2017−2020 ausgerichtet werden.

[5] Beim ILL ist ein schrittweiser Rückzug geplant. Der Entscheid betreffend die Weiterführung und den Umfang der Schweizer Beteiligung an «ILL 2024−2028» muss einerseits den beim Bau der European Spallation Source ERIC aufgetretenen Verspätungen und andererseits den Bedürfnissen der Schweizer Forschenden in Bezug auf den Zugang zu hochwertigen Neutronenstrahlenquellen Rechnung tragen.

[6] Die allfälligen Beiträge der Schweiz haben keinen Einfluss auf das BFI-Budget der Periode 2021−2024. Das SBFI plant jedoch einen Bundesbeitrag an die Tätigkeiten des CERN zur Unterstützung der Infrastruktur LBNF-DUNE. Dieser soll mit Mitteln finanziert werden, über die die Schweiz beim CERN bereits verfügt.

[7] Eine Beschreibung von ELI ist in Anhang B1 bei den Organisationen, zu denen der SNF Stellung bezogen hat, zu finden.

[8] In Bezug auf die künftigen finanziellen Beiträge der Schweiz an die EU im Rahmen von ITER/Fusion for Energy über 2020 hinaus wurde noch keine bindende Verpflichtung eingegangen. Die für die Periode 2021−2024 geschätzten Beiträge sind aufgeteilt auf eine bereits geplante Zahlung (29 Mio. CHF) und eine Zahlung, die sich aus den zusätzlichen Kosten im Zusammenhang mit dem Bau von ITER ergibt (110 Mio. CHF).

Die Schweiz prüft für die aktuelle Periode eine mögliche Beteiligung (nicht zwingend in Form eines Beitritts zur Organisation) an folgenden Organisationen:

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

Wichtige Anmerkungen:

1) **Die hier aufgeführten Finanzzahlen für die BFI-Perioden 2021−2024 und 2025−2028 sind Planzahlen. Sie dienen einer groben Abschätzung der voraussichtlich anfallenden Kosten und deren Verteilung.**
2) **Letzte Aktualisierung der Informationen: Juli 2018**

[75] ELI ist in Anhang B1 im Zusammenhang mit den Organisationen beschrieben, die Gegenstand einer Stellungnahme des SNF waren.

European Organization for Nuclear Research (CERN)

Description

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

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

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

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

National relevance

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

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

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

Funding

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

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

European Southern Observatory (ESO)

Description

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

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

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

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

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

National relevance

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

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

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

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

Funding

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

* The Swiss represents its membership contribution and contributions to ELT (Extremely Large Telescope).

European Synchrotron Radiation Facility (ESRF)

Description

The ESRF (https://www.esrf.eu/) is one of the world's largest synchrotron science centres. Every year, 7000 scientists from 22 partner countries and from around the world travel to Grenoble to use ESRF's extremely brilliant X-rays for leading-edge research activities. ESRF operates 44 beamlines exploiting the full range of X-rays related experimental techniques and provides its user a large scope of services. Since 2017, the organization also operates a high-end cryoelectron microscope.

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

ESRF scientific output includes more than 1800 scientific publications per year, of which more than 300 in high-impact journals, ranging over a broad spectrum of research areas, such as hard and soft condensed matter science, applied material science, chemistry, structural biology, medicine, Earth and environmental sciences, cultural heritage. Moreover, ESRF conducts its own research on synchrotron physics, synchrotron methods and instrumentations, and soft matter structure.

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

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

National relevance

ESRF is one of the leading world-class synchrotron radiation facility providing unique beam characteristics and instruments. Swiss researchers from over 20 institutes and research centres use circa 4% of the ESRF available beamtime for their investigations and experiments. The vigorous Swiss use of the ESRF attests the complementarity for Swiss researchers of the access to the ESRF with the availability of the Swiss Light Source (SLS) at the Paul Scherrer Institute (PSI).

Synergies between ESRF and SLS shall be leveraged as the ESRF will undergo in 2019 and 2020 a 21 months long shut down in the context of the EBS upgrade, as well as during the foreseen shut down of the SLS due to the coming implementation of the upgrade SLS 2.0.

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

Funding

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

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

Development phases

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

Institut Laue-Langevin (ILL)

Description

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

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

The 3 states that are parties to the ILL protocol are France, Germany and the United Kingdom. Italy, Spain, Switzerland, Poland Austria, the Czech Republic, Hungary, Slovakia, Belgium, Denmark and Sweden have concluded time-limited partnerships with ILL.

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

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

National relevance

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

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

Funding

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

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

European X-Ray Free Electron Laser (European XFEL)

Description

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

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

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

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

National relevance

Besides the purely scientific interest (covering many fields: physics, structural biology, material sci-ences, etc.), European XFEL is very relevant for Switzerland because of its complementarity with SwissFEL, which is also a free electron laser that was built lately at Paul Scherrer Institute. During the planning and construction phase, SwissFEL has largerly profited from the expertise of European XFEL and vice versa. There is an ongoing exchange between both infrastructures.

Funding

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

* Construction and operation
** Operation

Development phases

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

European Spallation Source ERIC (ESS)

Description

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

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

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

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

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

National relevance

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

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

Funding

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

* Membership contributions

Development phases

Design	Preparation	Implementation	Operation
Till 2011	2011-2015	2015-2026	2023-

European Molecular Biology Laboratory (EMBL)

Description

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

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

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

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

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

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

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

National partners/stakeholders: all Swiss universities and institutions active in the field of the organisation, young researchers that would want to work at EMBL.

National relevance

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

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

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

* Membership contributions

European Life Science Infrastructure for Biological Information (ELIXIR)

Description

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

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

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

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

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

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

National relevance

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

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

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

Funding

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

* Contribution towards the ELIXIR Hub in UK

Development phases

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

[76] European Molecular Biology Laboratory.

International Experimental Fusion Reactor (ITER)

Description

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

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

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

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

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

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

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

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

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

F4E members are Euratom (represented by the European Commission), the 28 EU Member States and Switzerland. Switzerland participates therefore to the construction of ITER, through F4E. Switzerland is represented by the EU in the governance of IO, as all the EU Member States are.

National relevance

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

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

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

The participation of Swiss private and public institutions in the ITER construction generates an interesting industrial return. Over the period 2007-2017 the estimated industrial return reaches 135 MCHF, i.e. 85% of the 159 MCHF Switzerland invested so far in ITER.

Funding

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

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

Development phases

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

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

Cherenkov Telescope Array (CTA)

Description

The CTA Observatory (http://cta-observatory.org) will be the ultimate generation of high-energy gamma-ray observatory. Up to 118 dedicated Cherenkov telescopes of three different sizes will be deployed on two sites: one on the ESO site of Paranal (Chile) and one on the Island of La Palma (Spain). CTA will be run as a European Research Infrastructure Consortium (ERIC) with Headquarter in Bologna (Italy) and a Data Management Science Center (SDMC) in Zeuthen (Germany). The Key Science Cases will be exploited by a Consortium of more than 200 research institutions in 31 countries with about 1420 members. The data, which will be distributed by the SDMC, will be open access and scientists will be able to request observation time through a competitive time allocation process.

Building up the full array should cost about 400 Million EUR, but future member states of CTAO ERIC agreed to start with the construction as soon as a threshold of 250 Million EUR is secured. This step should be reached in 2019. Full operation should not be reached until 2025. Contributions to the construction of CTA shall largely be in-kind, allowing research institutions to get involved in the conception of instrumentation and delivering benefits to industry among member states. It is foreseen to operate CTA for at least 30 years. CTA represents also a computing challenge: the total volume of data to be managed by the Observatory archive will be of the order of 25 PB per year.

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

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

National relevance

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

The scientific relevance of CTA for Switzerland and the world is enormous, in the data frame and analysis techniques, including machine learning and modern imaging techniques, and to set contacts with specialized industries which could participate to the construction of telescopes. In the coming future,

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

Swiss Institutions involved in CTA will be heavily involved in the construction and testing of telescope elements trying to cooperate at most with local industry.

A funding line of 8 Million CHF has been reserved in the ERI Dispatch 2017-2020 so as to pave the way towards the accession of Switzerland to the CTAO ERIC. Sharing of contributions isn't settled yet though. SERI participates in ongoing negotiations towards the establishment of CTAO ERIC with the other expected future Member states and organisations (DE, FR, IT, UK, SL, CZ, PL, ES, JP, TH, ESO).

Development phases

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

Square Kilometer Array (SKA)

Description

Description

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

Building up the full SKA should cost a few Billion EUR. However, the SKA will be built in two main phases. The first phase (SKA1) will involve testing the full system in a "proof of concept" manner. For SKA1, Australia will host the low-frequency instrument with more than 500 stations, each containing 256 individual antennas, whilst South Africa will host an array of some 200 dishes, incorporating the 64-dish MeerKAT precursor array (in operation since July 2018). The cost of SKA1 has been capped at 650 Million EUR in 2013 value. Its construction should start in mid-2020 and its full operation should not be reached until 2025. The second phase (SKA2) is still under discussion. It will complete the telescope arrays at both sites so that SKA can operate some 2000 high and mid frequency dishes and aperture arrays and a million low-frequency antennas. Already SKA1 will be a huge "big-data" challenge: the total volume to be managed by the Observatory archive will be of the order of 300 PB per year. Very high-performance central supercomputers capable of more than 100 petaflops of raw processing power will be required, stretching technology to its absolute limits.

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

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

National relevance

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

In the framework of the 2015 Roadmap, the SKA has been identified as an important large research infrastructure for which the participation of Switzerland is to be considered. Since 2016, SERI attends as observer the meetings of the SKA Board of Directors. The ETH Board supports the insertion of a funding line dedicated to SKA in an ERI dispatch. Sharing of contributions is not settled yet. Also since 2016, the Swiss SKA community organizes with the support of EPFL annual "Swiss SKA Days"

(ska.epfl.ch) during which a number of Swiss industries and start-ups have shown strong interest in the SKA project.

Development phases

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

Neutrino experimental facilities in USA and in Japan

Description

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

LBNF/DUNE

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

Two complexes will be built, with a “near” site facility at Fermilab and a “far” site at the Sanford Underground Research Facility (SURF). The world’s most intense beam of neutrinos will be produced at Fermilab and aimed at the SURF site at a distance of 1300 km from Fermilab. The design of the LBNF/DUNE facilities and detectors are driven by the primary scientific goals of carrying out a comprehensive program of neutrino oscillation measurements, besides also significantly improving the search sensitivity for proton decays, detecting and measuring neutrinos from core-collapse supernovae and be ready for unexpected discoveries. One main goal is to reach sensitivity to measure charge-parity symmetry violation (CPV) in neutrino oscillations, which would give insight into the origin of the mentioned matter-antimatter asymmetry.

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

LBNF/DUNE is a global organization with currently 1100 scientists and engineers from 175 institutes in 31 countries, with 3% of the members from Switzerland.

The main excavation at the far site in South Dakota has started and the beginning of beam operation is planned for 2026 and will last for at least 10 years. The total construction cost of LBNF/DUNE is estimated at around 2500 million USD.

HyperK

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

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

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

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

National relevance

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

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

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

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

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

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