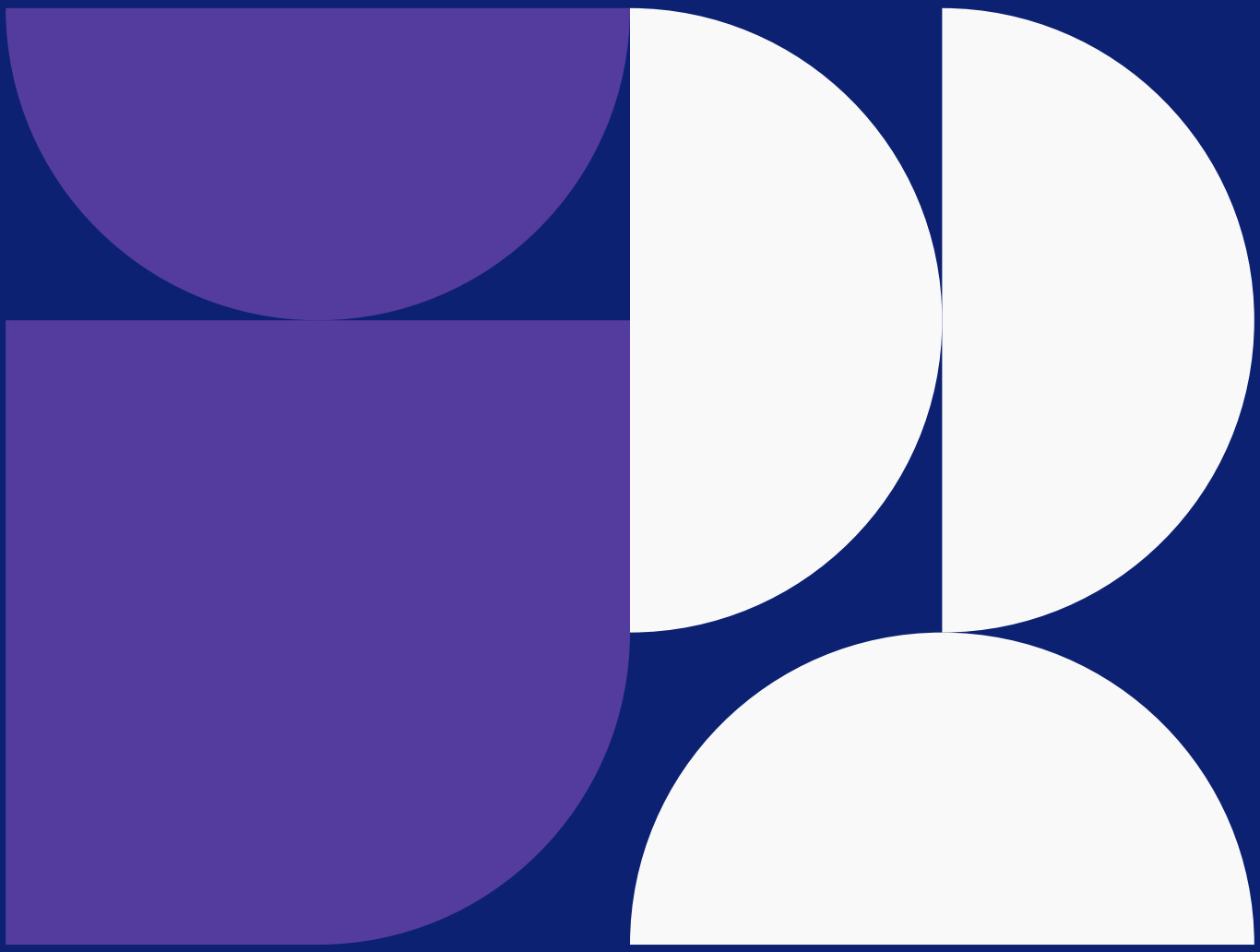
Analysis of processes for prioritisation and funding of research infrastructure



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Analysis of processes for prioritisation and funding of research infrastructure

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Content

Foreword

Research infrastructures are of fundamental importance for the research community, and access to research infrastructures constitutes a prerequisite for high quality research. With the development of advanced cutting-edge technologies, and the collection and sharing of data and resources, the cost associated with research infrastructures has changed dramatically. However, the resources to fund research infrastructures have not increased at the same rate, and there is an increasing gap between funding and perceived needs by the research community.

In the recent research bill (Prop.2024/25:60), the Swedish Government acknowledges the increasing needs and places emphasis on improving the access to research infrastructures for the Swedish research community. The Swedish Research Council is committed to developing the handling, prioritisation and funding of research infrastructures to better serve the changing needs of the research community. Long-term investments need to be made, and at the same time there should be flexibility to meet new or changing needs. The infrastructure landscape has changed from being dominated by single-site big science infrastructures to include an increasing number of distributed infrastructures. Furthermore, the need for infrastructures in research fields that have not traditionally used infrastructures is increasing.

To learn from other countries how they meet the challenges in funding infrastructures that we are experiencing in Sweden, we commissioned a report analysing the processes used by other countries to prioritise and fund research infrastructure. As the report discuss, most countries investigated have similar challenges to those we experience in Sweden. Each country has an approach to meet the challenges that varies depending on the prerequisites of the specific country. One clear outcome of the analysis is that the countries included in the investigation all have a roadmap, that strategically points out the direction of future investments and prioritisations. We have started to map out the current Swedish infrastructure landscape of national infrastructures as a first step towards a strategic roadmap.

We wish to thank Prof. Taina Pihlajaniemi for taking on this task with great enthusiasm and for interesting discussions. We would also like to thank all the persons who took part in the interviews for taking the time to discuss and provide insights into national processes.

Stockholm, 15 December 2025

Katarina Bjelke
Director General

Summary

The Swedish Research Council tasked the investigator to make an analysis of processes for infrastructure prioritisation and funding in several appointed countries and organisations. The analysis consists of a brief overview of the funding system in seven countries, followed by a thematic discussion of processes to support a holistic understanding of the infrastructure landscape, processes for prioritisation of research infrastructure (RI), and processes for funding. Finally, the analysis provides recommendations for the development of the Swedish system of research infrastructure funding.

The strategic need for structured RI policies and funding was found to be in a highly dynamic state, as in all countries examined the national infrastructure roadmaps were in the process of being updated in 2024-2026. The importance of RIs in supporting competitive research in all fields, also those traditionally not relying on RIs, is now well understood and this is also reflected in increasing needs for government funding.

The criteria for national RIs are very similar for each country, including promotion of high-quality science, wide impact in the scientific community and in society as a whole, provision of skilled services and open access. International evaluations are used in most countries to assess the applications submitted. Furthermore, the 21st century has marked a paradigm shift, where science has become more networked, flexible and reconfigured. This is also reflected in the RI policies where, alongside large-scale discipline-specific RIs, such as synchrotrons and telescopes, there has been explosive growth in distributed RIs. Addressing global challenges requires multi- and interdisciplinary cooperation, which has led to evolving interconnectedness and interdependencies of RIs and research communities. RIs often forms a jigsaw puzzle, where local, national, and international RIs merge to form the full picture of service and access needed by the R&D communities.

Sweden is internationally recognised as strong scientific contributor. The recommendations include building a holistic understanding of the state-of-the-art infrastructure landscape and new needs in Sweden to better steer the future perspectives in research excellence and deciding on the best use of national resources. Along with this process, it is recommended that joint planning of RIs is strengthened among researchers, within and across disciplinary fields, the host institutions, and the funding bodies.

Access to international RIs is critical for high-class research in many fields. Swedish participation in the global and European RI partnerships and its roles as host of international RIs requires further strategic planning to exploit the collaborations more efficiently scientifically, and to increase economic competitiveness.

It is widely recognised that long-term stability is essential for RIs. On the other hand, entirely new RI needs may emerge. Geopolitical concerns affect RI planning and strategic prioritisation and will require the processes to be increasingly flexible and agile. In the case of evident long-term operations, this could entail granting longer funding periods for part of the RIs.

The dramatic growth in scale and complexity of data sources supporting R&D is creating needs for cyber RIs with advanced computing, data storage, software development, networks, and standards. The digital transition to the "lab of the future" taps to the explosively growing data universe, and the use of artificial intelligence and machine learning in modelling, simulation, and digital twinning is a game-changer. While advanced national computing and data solutions exist in Sweden, there remains many unsolved issues that require coordination across disciplines to provide open access to data and to identify synergies between fields, as well as better coordination within disciplines and in linking national services to local operations.

Expenses for open science includes costs for open publishing and data storage, and the expertise needed for data management. Efficient and transparent models for sharing the costs need to be developed.

Today´s high-end RIs require a technically proficient workforce to develop and run the operations, as well as to provide knowledgeable services to a wide user community. One of the recommendations is to develop clear and respected identities for the various personnel groups providing RI services.

Finally, to achieve greater impact and societal relevance, RIs should be encouraged to align with relevant R&D&I ecosystems that range from academic research to industry-led research.

Sammanfattning

Vetenskapsrådet har givit en extern utredare i uppdrag att göra en analys av processer för prioritering och finansiering av forskningsinfrastruktur i ett antal länder och organisationer. Analysen består av en kort översikt över finansieringssystemet i respektive land, följt av en tematisk diskussion om processer för att stödja en helhetsförståelse av infrastrukturlandskapet, processer för prioritering av forskningsinfrastruktur och processer för finansiering. Analysen avslutas med rekommendationer för utvecklingen av det svenska systemet för finansiering av forskningsinfrastruktur.

Samtliga länder som ingick i analysen uppdaterar någon gång under perioden 2024-2026 sina nationella strategier eller 'road maps' för forskningsinfrastruktur. Strategiska frågor om forskningsinfrastruktur står därmed högt på den forskningspolitiska agendan för fler länder än Sverige. Forskningsinfrastrukturernas betydelse för att stödja konkurrenskraftig forskning inom alla forskningsområden, är ett väl identifierat behov, vilket återspeglas i ökande behov av statlig finansiering.

Kriterierna för vad som anses vara nationell forskningsinfrastruktur är mycket lika mellan de undersökta länderna. Det inkluderar främjande av högkvalitativ vetenskap, bred genomslagskraft i forskarsamhället och i samhället som helhet, tillhandahållande av kvalificerade tjänster och öppen tillgång till forskningsinfrastrukturernas tjänster. Internationella experter används i de flesta länder för att bedöma ansökningar om finansiering av forskningsinfrastruktur. Millenniumskiftet har markerat ett paradigmskifte där vetenskapen har blivit mer nätverksbyggd och dynamisk vilket förändrat landskapet. Detta återspeglas i att det, vid sidan av storskaliga forskningsinfrastrukturer såsom synkrotroner och teleskop, har skett en explosionsartad tillväxt av distribuerade forskningsinfrastrukturer. Dessutom bildar forskningsinfrastrukturer ofta ett ekosystem där lokala, nationella och internationella infrastrukturer smälter samman till ett landskap av service för forskningen.

Sverige är internationellt erkänt som en ledande forskningsnation. Rekommendationerna som rapporten leder fram till inkluderar att bygga en helhetsförståelse av infrastrukturlandskapet och utifrån det identifiera behov för att säkerställa fortsatt forskningsexcellens. En helhetssyn på infrastrukturlandskapet kan utgöra underlag för en gemensam planering av resurser till forskningsinfrastruktur mellan olika intressenter.

Dagens avancerade forskningsinfrastruktur kräver en tekniskt kompetent personal för att utveckla och driva verksamheten, samt för att tillhandahålla användarstöd till alla relevanta användargrupper. En av rekommendationerna är att utveckla tydliga karriärvägar för de olika personalgrupper som tillhandahåller service och tjänster inom forskningsinfrastrukturer.

För att uppnå större effekt och samhällelig relevans, bör forskningsinfrastrukturer uppmuntras att anpassa sig till relevanta forsknings-, utvecklings- och innovationsekosystem som sträcker sig från akademisk forskning till industrirelaterad forskning.

Introduction

The analysis is based on information gathered through the national strategies/strategic research infrastructure roadmaps of seven countries, but other types of reports or documentation of processes were also used. The countries investigated were Denmark, Finland, Netherlands, Norway, Sweden, United Kingdom, and United States of America. In the case of each country, interviews with officials responsible for national infrastructure strategies and funding processes were also central to the analysis. The analysis also includes the ESFRI activities. The list of literature used is presented at the end of the report.

The method of analysis was agreed upon in discussions between the investigator and representatives of the Swedish Research Council, which also supplied a set of key documents of relevance to the Swedish system and to the countries being investigated. In discussions with the investigator, the Swedish Research Council also helped to identify relevant persons to interview. The interviews served to obtain more in-depth understanding of how strategic processes have been developed and implemented. The persons interviewed are listed at the end of the report.

The report consists of five parts: A brief overview of the funding system in each country; Processes to support a holistic understanding of the infrastructure landscape; Processes for prioritisation of research infrastructure; Processes for funding; and Recommendations for the development of the Swedish system of research infrastructure funding. The recommendations are the investigator’s conclusions, formed by considering the information gathered and best practices observed. The analysis begun in July 2024, and the conclusions were presented in November 2024.

1 A brief overview of the funding system in each country

For each country, a short description of the overall structure of the funding system for research infrastructure (RI) is provided. It describes the main funding streams and how they interact. For example, what government funding is provided, by which principles is it distributed, and whether non-governmental funders contribute to the system.

The overview also describes how local infrastructure (shared by researchers at a university/research institute), national infrastructure (shared by researchers from different universities/research institutes), and international memberships (access to international infrastructure or collaborations for data collection, etc.) are handled and funded. Comments are also made on how currency fluctuations in relation to international memberships are handled.

This overview combines information derived from publicly available roadmaps and other relevant materials, and some information obtained during interviews.

1.1 Denmark

1.1.1 Strategy for funding and structure of the funding system

The “Danish Roadmap for Research Infrastructure 2020” provides a series of strategic objectives and specific milestones for the upcoming years as well as outlines for 16 new national infrastructures. The roadmap is the third of its kind, preceded by roadmaps from 2011 and 2015. Compared to the previous roadmaps, the 2020 roadmap subjects all proposals to international peer review. The roadmap was prepared by the Danish Agency for Higher Education and Science. The Agency received advice from the National Committee for Research Infrastructure (NCRI), which has wide national representation including representatives from all universities. The National Fund for Research Infrastructure (NFRI) finances the infrastructure. The roadmap is an instrument for the strategic prioritisation of funding for the RI area and forms the basis for international collaboration on RIs.

Roadmaps are prepared at four-year intervals, and an open call is ongoing for proposals for the 2025 Roadmap for Research Infrastructures. As part of the roadmap process, the universities are asked to propose their most strategic RI plans and include substantial co-funding, which taken together ensures inclusion of major scientific needs in the roadmap. The interview revealed some concern about the handling of possible new needs emerging during the roadmap intervals.

Systematic mapping of Danish RIs has not been carried out, but an extensive database of Danish test facilities in different disciplinary fields has been set up. Preparation of the roadmap included analysis of the returns from Danish membership of major international infrastructures, mapping the financing landscape, and analysing investment by NFRI. In terms of international infrastructures, the Danes are among the most able at exploiting the opportunities that the memberships offer. However, there is a general absence of strategies and action plans to exploit the memberships.

The 2020 Roadmap has headings describing objectives and milestones with concrete goals. The roadmap outlines two main objectives targeting national and international RIs, both accompanied by several milestones including specific initiatives to be implemented in the coming years. The milestones of concern to the national objectives relate to the basis of new investments, research data, capacity, and conducting a survey of existing infrastructures. The milestones of concern to the international objectives relate to the establishment of two new national centres for supporting activities, setting targets and monitoring returns, strengthening commercial returns, promoting greening of infrastructures, and participating in more European RIs. Green transition and contributions towards solutions of major societal challenges are important ambitions.

A portfolio of 16 new and significant upgrades of national RIs is listed in five areas. 29 proposals were received and evaluated by international panels, whereupon the NCRI provided advice to the Ministry of Higher Education and Science, which independently formed the final decision. The proposals were requested to be attainable in five years and have wide national added value. All fields were covered, and by now all roadmap RIs have received funding. Universities are the main hosts of the RIs, and the RIs are requested to report yearly on their activities.

RIs contribute to attracting and retaining talent, and they support collaborations between researchers in universities and other institutions and businesses. The Danish system has invested in structures to support such added values. Five national accompanying centres, in the form of consortia between the universities, help the scientific community to use the large international RIs, for example by funding travel expenses related to the use of RIs. The significance of RI on innovation and business can be divided into “upstream” (tenders, procurement, developing roles) and “downstream” (use and research collaborations) phases. BigScience.dk supports Danish companies’ interaction with research infrastructures.

1.1.2 Funding

In 2024, the total funding was 875 million DKK. This funding supports national infrastructures, including new and digital infrastructures, other national research infrastructure collaborations, and contributions to major international infrastructures. The typical level of funding decisions per RI are 30-100 million DKK, and at least 50 percent of matching funding is required. The funding decisions are done by the Minister.

The most expensive investment relates to the European Spallation Source (ESS) in Lund, Sweden, and co-hosted by Denmark. In 2024, membership fee for this accounted for 572 million DKK, 65 percent of the Danish Ministry of Higher Education and Science's funding for RIs. Of the remaining funds, the share to RIs included in the roadmap was 8.8 percent (77.1 million DKK), and that to computing for e-science 10.7 percent (93.8 million DKK). A new research vessel, DANA, received earmarked funding in 2021 (170 million DKK).

Contribution of non-governmental funders: Mapping of the financing landscape show that some of the Danish large private and public foundations provide separate funding for research infrastructures.

At local level, users are usually the university's or institution's own researchers and students. These can be significant to Denmark but are not funded as national RI. At national level, collaboration results in added value for the research infrastructure. International RIs are considered important, for the purpose of obtaining large national benefits from the international collaborations. This includes membership of six large international RIs, and 18 ESFRI infrastructures. Currency fluctuations do not have a major impact.

1.2 Finland

1.2.1 Strategy for funding and structure of the funding system

The "Roadmap for Finnish Research Infrastructures 2021-2024" is based on the "Strategy for National Research Infrastructures in Finland 2020-2030" and "The National Roadmap for Research, Development and Innovation". The first roadmap was published in 2009. The Finnish Research Infrastructure Committee (FIRI), embedded in the Finnish Research Council (FRC, formerly the Academy of Finland), has the tasks of monitoring and developing national and international RI activities, as well as selecting the roadmap RIs and deciding on RI funding. The FIRI Committee also coordinates external evaluations of the applications for infrastructure funding and makes the funding decisions.

The aim of the Research and Innovation Council, chaired by the Prime Minister, is to make Finland the most attractive and competent environment for experimentation and innovation by 2030, and for the share of research, development and innovation (R&D&I) to increase to 4 percent of GDP. RIs play an important role in building innovative and inspiring R&D&I and utilising research results, not only in science but also in society as a whole.

A portfolio of 29 RIs have been selected to the 2021-2024 roadmap. The number of organisations owning RIs has increased, even though the number of infrastructures in the roadmap decreased from 32 in 2014-2020. A new roadmap for 2025-2028 was presented at the end of 2024, resulting in further reduction of roadmap RIs to 21. Instead of separate calls for funding the latest roadmap call also included applications for funding. Thus, up to five years of funding will be granted to the selected RIs in the new roadmap. Moreover, the RIs that perform

best will be upgraded to “lighthouse infrastructures” during 2025. A major RI investment is represented by the EuroHPC JU, including the LUMI pre-exascale supercomputers, co-hosted by Finland.

New RIs are identified through open calls for RI activities of national and international importance. Separate comprehensive mapping of RIs has not been carried out, instead a picture of operations at national level can be obtained through the open RI calls. However, some specific surveys of RIs have been done, for example of the research institutes.

The interview raised emerging topics that relate to security, AI, quantum computing and an explosive growth in data science. It is also evident that a greater focus on the people responsible for the RIs is needed.

It has been noted by SITRA, the Finnish innovation fund, that new innovations do not occur in established companies but in start-ups, and their need for RI access is huge.

1.2.2 Funding

The estimated total funding need for the RIs on the roadmap for 2020–2030 is 2.7 billion EUR, about 250 million EUR annually. The FIRI Committee supports the construction and upgrading of RIs by 20 million EUR annually. However, a permanent increase in the funding level is anticipated. Membership fees for international RIs are also funded through the FRC every year, by approximately 20 million EUR.

Additionally, one-off funding of approximately 100 million EUR has supported Finland’s participation in the EuroHPC activities and the construction and development of national and local RIs on the basis of the Recovery and Resilience Plan that is part of the Sustainable Growth Programme for Finland. Moreover, the Ministry of Education and Culture and the Ministry of Economic Affairs and Employment have prepared a multi-annual plan for the use of research and development funding, which includes significant funding for quantum computing.

Bi-annual FIRI calls have been organised to support project-type funding and membership fees. Funding is based on international evaluation and competition. The funding targets mainly the roadmap RIs, but a smaller part of the funding targets proposals outside the roadmap. In the latest open call, 22 consortium RIs were funded, with an average amount of 2.3 million EUR per application, but the funding level varies. The required co-funding by the host is 30 percent.In addition to the regular calls, targeted funding schemes can be used, for example based on political considerations, such as a recent funding scheme directed at operators in eastern Finland to support regional development.

Contributions from non-governmental funders is low, only a few private and public foundations provide minor funding for RIs. Decommissioning of RIs is very rare, but the funding level may vary according to the life cycle of the RI.

At local level, the RI funding is largely the responsibility of the local operators. A special call based on Recovery and Resilience Funds has been organised, which supported local needs. There is a need to consider whether the local level requires attention also in the future, especially since the boundary between local and national is often not clear-cut. One of the characteristics of a national RI is that it is of broad national interest and has international impact.

Finland is a member of 30 international RIs, three of which are hosted by Finland. The membership fee structures differ, but the aim is to make five-year commitments. The returns/benefits have been estimated to exceed the membership fees. Currency fluctuations were not of importance. Moreover, the interview suggested that the RI structure often forms a jigsaw puzzle, where local, national and international RIs merge to form the full picture.

In 2020, a joint mapping of benefits from international infrastructure memberships by Swedish, Dutch and Finnish parties was carried out. The survey showed that the annual number of Finnish users of the international research infrastructure varied from 60 000 to 150 000 and they employed about 140 Finns (only 2 percent of the total).

1.3 The Netherlands

1.3.1 Strategy for funding and structure of the funding system

The “National Roadmap for Large-scale Research Infrastructure 2021” is an instrument for the Dutch government to make strategic choices about RIs at universities and national research institutions. The first list of infrastructures was presented in 2008. Moving from ad hoc processes, a Permanent Committee for Large-scale Research Infrastructures (PC-LRI) was established in 2015 by the Dutch Research Council (NWO) on behalf of the Ministry of Education, Culture and Science. Its tasks relate to guiding the roadmap processes and determining the strategic aspects of open RI calls. The first strategic National Roadmap was published in 2016. The 2021 Roadmap gave the research fields great responsibility for building the roadmap, and self-organisation and collaboration were stimulated. The next roadmap is now being discussed by the PC-LRI and anticipated for 2026, preceded by an update of the RI inventory.

In 2013-2019, the R&D intensity of the Netherlands was around two percent of GDP. The 2021 Roadmap states that the Dutch government aims to increase its investments in R&D in the context of a National Growth Fund and the European Recovery & Resilience Fund. Moreover, the PC-LRI has recommended that the Government reserves additional funding for the implementation of the 2021 Roadmap for the realisation and substantial updating of large-scale RIs (LRIs), as well as for funding the participation of Dutch roadmap LRIs in international memberships.

An inventory of LRIs was commissioned via the boards of all universities, national research institutes and national institutes. The definition of an LRI

includes a central access point, a management board, a legal structure, and capital investment and operating costs for five years amounting to at least 10 million EUR. This inventory resulted in 146 proposals and, of these, 122 fulfilled the LRI criteria and were included in the LRI Roadmap. Compared with the 2016Roadmap, the number of LRIs in the 2021 Roadmap is lower, because of some infrastructures having clustered.

The 2021 Roadmap is based on three domains, including nine groups of thematic and technical commonalities that were clustered by the PC-LRI, based on the landscape. Researchers representing the nine groups were requested to identify, bottom-up, the LRI plans most in need of investment over the next ten years. Altogether, 59 RI plans are listed. Through this “group process” the main responsibility for preparing the roadmap was placed in the hands of the research field, including prioritising plans for the next five years, and where relevant, describing how the LRI plans relate to ESFRI initiatives. This process was considered to ensure widely supported strategic choices with respect to the LRIs. The groups continue to have a critical role in preparing for the funding calls.

There are differences in the types of infrastructures between the domains. In engineering and natural sciences, the LRIs mainly concern hardware, and more than two-thirds of the LRIs in this area are completely international in nature. Only 50 percent is operational, as it takes a long time to design and construct these initiatives. In life and medical sciences, there is huge diversity among the infrastructures, with about 15 percent consisting of distributed databanks, databases and electronic services. A Dutch federated cohort is being planned. Some are completely international, but three-quarters are largely national in nature. Eighty to ninety percent is already at the exploitation phase, and over half are part of collaborations of complementary infrastructures spread across several locations. The vast majority of the LRIs in social sciences and humanities are digital, distributed databases. More technologically-focused infrastructure is represented by a new heritage LRI linking with European plans. One-fifth of LRIs span several domains, including various sample collections and large equipment. Decommissioning of RIs is rare, it is more common for RIs to further develop it activities or of RIs to merge.

Besides the LRIs in the Roadmap, there are 5 international RIs that are handled by the ministry: CERN, ESA, EMBL, ESO and a new large-scale commitment to join the Einstein telescope project.

The international RIs participated in a survey that was partially conducted jointly with the Swedish Research Council and the Academy of Finland in 2020. This was continued in the Dutch context. The analysis of the 47 memberships confirms the importance of Dutch participation in international research infrastructures. There is an ongoing assessment of the international RI membership portfolio to decide how to cover the need for such participations.

1.3.2 . Funding

The roadmap states that there is a dire need for new investment in LRIs in all research areas. Two (multi-annual) funding competitions in the roadmap period of 2021-2025. The funding allocation is 40 million EUR per year. An important Government decision increases this to 65 million EUR for the upcoming calls until 2031. Moreover, a substantial additional budget has been created for digital infrastructures (see below). The allocation for the individual domains is 45 percent for engineering and natural sciences, 45 percent for life and medical sciences, and 10 percent for social sciences and humanities. Applications are made by consortia associated with groups on the roadmap.

Importantly, the roadmap calls are restricted to two per each of the nine groups in the roadmap; this prioritisation must be made by the groups heading each area. An emphasis is thus placed on prioritisation by the researchers prior to making the call. Thus, only 18 applications are submitted. In addition, it is possible to submit a few cross-disciplinary applications. An international committee assesses and ranks the applications, and about half will receive funding.

The amount of funding applied for can be a minimum of 10 million EUR, and a matching contribution of at least 25 percent of the total project cost is required. Typical funding levels are 15-20 million EUR per RI.

Besides the roadmap funding, another NWO funding instrument targets national consortia applying for innovative smaller RIs. The grant amount is a minimum of 1 million EUR for social sciences and humanities, and a minimum of 1.5 million EUR for the other domains. A 25 percent matching contribution is required. These calls take place every two years, and the total funding is about 20 million EUR. Many applications are received, and the success rate is only 10-15 percent. For both funding streams, the funding is not intended for research costs.

Digitisation was targeted with a one-off payment of 40 million EUR and a structural amount of 20 million EUR per year for high-performance computing, and the setting up of local digital competence centres and three thematic digital competence centres that bring together the three domains of science.

In addition, NWO has other funding streams that provide some room for infrastructure as part of a research grant proposal. The Knowledge and Innovation Covenant Long-Term Programmes (KIC-LTP) funding stream targets public-private consortia that can apply for 10-year research programmes in an amount of 9-25 million EUR, of which NWO can fund 30 percent and private parties are expected to contribute at least 30 percent. Moreover, other ministries also fund RIs, but typically those of more applied nature, for example the Ministry of Economic Affairs. Furthermore, EU funding, especially from Pillar I, can be applied for. Non-governmental funding is not elaborated in the roadmap, but the KIC-LTP provides a way of joining interests between public and private parties also with respect to infrastructure.

Influence from currency fluctuations only applies to the membership in CERN but there is an agreement that secures the funding needed.

1.4 Norway

1.4.1 Strategy for funding and structure of the funding system

The "Norwegian Roadmap for Research Infrastructure 2023" encompasses a 15-year perspective. The roadmap is largely a continuation of previous priorities and principles, with added details about EOSC and EuroHPC. The roadmap was prepared by the Research Council of Norway under the auspices of the Ministry of Education and Research. The roadmap relates to the Government's long-term plan for research and higher education for 2023-2032. The national Funding Initiative for Research Infrastructure was established in 2009 (inspired by the ESFRI process) and, using wide consultation, the roadmap is updated prior to each call for proposals. The 2023 edition being the seventh in a row. In 2014, the funding for infrastructures increased, as Norway was identified to fall behind in the development of RI resources in comparison to many other countries, and a structured process has followed. The governmental long-term plan is updated every four years, based on wide-ranging stakeholder consultation. In interviews, the Ministry representatives state that they are very satisfied with how the Research Council works, with their evaluations, etc.

The division of thematic and technology areas follows the ESFRI roadmap, but with some adjustments addressing specific national needs. The roadmap points to world-class leadership in polar, maritime and sea-food research. Moreover, certain national needs are highlighted, such as the petroleum industry and ocean-related activities. An overriding consideration is maintaining the Arctic as a peaceful and stable region. In humanities, the thematic priorities include societal security and trust. The roadmap is a list of RIs under establishment or in operation.

1.4.2 Funding

At present (2023), the National Funding Initiative for Research Infrastructures has an annual budget of approximately 800 million NOK. Maintaining this level is considered important. This includes certain infrastructures decided on at governmental level: ECCSE, CESTA, ESS, EISCAT, and a few infrastructures at Svalbard.

RI funding is provided through open calls, and the prioritisation process emphasises both scientific quality and strategic relevance. More targeted calls may also be used. The Research Council funds infrastructure applications from 2 million NOK up to 200 million NOK. A typical funding level is 50-60 million NOK per RI. Funding exceeding 200 million NOK is decided on at ministerial or governmental level. Data management infrastructure is also included in the Council's funding.

Some large, nationally important infrastructures are considered ahead of others in the funding allocation process. Co-funding is not required and operating costs are not considered, except in a few cases with very high costs this may be motivated. Funding is not provided for infrastructures that mainly target economic activities, collection of data through population surveys. The roadmap serves as a quality stamp for other ministries, for example for operating cost funding provided by another ministry. Funding from industry is a lot lower than in Denmark, Sweden or Finland. Occasionally, an instrument may be funded by a company.

There are no clear examples of decommissioning, but regarding distributed RIs, some local nodes may "fade away". Decommissioning of the old EISCAT radar is ongoing but essentially the same international consortium has initiated the planning and building of a new type of radar, the EISCAT_3D.

At local level, basic infrastructure at the R&D institutions should be funded by the institutions themselves. However, the Research Council may cover a proportionate share of depreciation for these infrastructures, and project-specific infrastructure may also be funded. National collaboration is considered necessary for several infrastructures. This includes considering actors from industry, public administration, or health trusts. Internationally, there principles set up for Norwegian membership in RIs on the ESFRI roadmap. Currency fluctuations are considered a technical issue and part of the Ministry's budget submitted to the governmental financial planning.

1.5 Sweden

1.5.1 Strategy for funding and structure of the funding system

The Council for Research Infrastructures (RFI) at the Swedish Research Council has overall responsibility for Sweden's national RIs and participation in international RIs. The "Swedish Research Council's Guide to Research Infrastructure 2023" describes the strategic assessments and recommendations considered to be necessary to ensure that Swedish researchers in all scientific fields can continue to have access to modern, high-quality RI. The guide is written by RFI. The guide published in 2023 presents nine recommendations, as well as a number of suggestions aimed at improving the work on both identifying needs for new RI of national interest, and also on prioritising investments in RI. It emphasises the importance of Swedish return on investment, both in relation to knowledge and competence, and to economic returns, from Sweden's membership in international RIs.

There is no complete mapping of what infrastructures are accessible for researchers in Sweden, nor of their funding. The guide lists infrastructures funded by the Swedish Research Council divided into nine subject areas. This, however, does not constitute a specified RI portfolio.

Collaboration between higher education institutions (HEIs) and the Council is organised through the Universities Reference Group for Research Infrastructure (URFI), which plays an important role in the strategic stakeholder dialogue, including contributing to the inventory of research infrastructure needs.

Big Science Sweden (BiSS) is an organisation funded by the Swedish Research Council and the Swedish Innovation Agency (Vinnova), tasked with broadening the networks and collaborations between Swedish high-tech companies, HEIs, research institutions and large infrastructure facilities. They also support Swedish actors to be successful in winning contracts at Big Science facilities, such as CERN.

1.5.2 Funding

The Swedish Research Council is currently funding a significant proportion of the national and international RIs used by Swedish researchers. Other governmental research funding bodies, such as Vinnova, contribute to some extent but the emphasis may be different, such as on funding test beds rather than infrastructures serving scientific research.

In 2023, the Council allocated about 2,8 billion SEK for RIs, over one-third of this represented funding to ESS (1 billion SEK) and 560 million SEK to convention-bound international memberships (CERN receiving the greatest amount), while the major national RIs MAX IV and NAISS received nearly 500 million SEK. The share of other national RIs was 620 million SEK. Funding is typically allocated for four to five years. Recent funding decisions have targeted support to humanities and social sciences for their increasing RI needs. Co-funding for national RIs by HEIs amounts to no less than 50 percent of total costs.

The Council's funding model for RIs follows a two-year funding cycle, starting with a needs inventory and ending with a targeted call. The research community is now accustomed to this process, but discussion is also in progress on modifying the process, especially regarding long-term RIs.

Contributions from non-governmental funders is limited but for example the Knut and Alice Wallenberg Foundation might contribute with funding for RI in specific focus areas where they intend to support strong research environments.

Investments in large-scale infrastructures in Sweden such as ESS, MAX IV, EISCAT-3D, and NAISS are significant commitments considered to be of great importance to Sweden and its international visibility.

According to the guide, the operation of all infrastructures is always done in an international context, where the interaction between national and international interests is an important driver. A strict division into national and international RIs can therefore not be done. HEIs have the responsibility for fulfilling the needs for local infrastructure.

National infrastructures carry out their operations at a single site, central node or distributed across several HEIs. The greater majority of the national RIs are funded via grants in the call for “infrastructure of national interest”. Some are funded by separate arrangements (such as MAX IV and NAISS).

The challenges posed by the COVID-19 pandemic, the geopolitical situation, and the weak Swedish currency have meant that the preconditions for many RIs have changed rapidly. The currency fluctuations pose major challenges, impeding especially the amount of funding available for national RIs, and calling for greater flexibility in handling currency changes.

1.6 United Kingdom

1.6.1 Strategy for funding and structure of the funding system

A comprehensive RI effort became possible with the formation of UKRI, UK Research and Innovation, launched in 2018 to merge seven discipline-specific research councils, Research England (supporting research and knowledge exchange at higher education institutions), and the UK’s innovation agency. This represents a significant streamlining of different governmental organisations for funding research and innovation. With the new organisation and a national strategy, it appears that RI policy and funding is well embedded in the Government and gets the attention that it needs.

The research and innovation infrastructures are considered to contribute broadly to the Industrial Strategy (2019) that sets the ambition for the UK to be the world´s most innovative economy and states the goal for the Government to raise total R&D investment to 2.4 percent of GDP by 2027, essentially doubling its level. The Industrial Strategy emphasises four grand challenges: AI and data, clean growth, future mobility, and an ageing society.

“The UK’s research and innovation infrastructure: opportunities to grow our capability”, a roadmap report published in 2023, presents an overview of where to invest and identifies R&I infrastructure priorities up to 2030. It outlines six sectors that are aligned with the ESFRI activities: biology, health and food; physical sciences and engineering; social sciences and arts and humanities; environment; energy; computational and e-infrastructure. In addition, a group of large-scale facilities serving wide multidisciplinary use are described.

An important consideration is targeting all research fields and considering the diversity of RIs, both existing ones and new developments. One of the outcomes of the roadmap and subsequent funding has been a major impact in the fields of humanities and social sciences, which have been targeted with new major investments.

The focus is on excellence, strategic drivers, value and deliverability for industry, use of independent advice on decision making, life cycles, maintaining flexibility, supporting early-stage scoping, the importance of international

collaborations and partnerships, and taking into account energy efficiency and sustainability.

The roadmap process included an analysis of the UK's RI landscape in 2018 to 2019, which was found to be extremely diverse, with 527 nationally and internationally significant infrastructures, with 92 percent of these working across multiple domains, 75 percent with businesses and 42 percent with public policy, and 60 percent with an expected life expectancy of over 25 years and 78 percent over 15 years. The RIs employ just under 25 000 staff.

To identify new needs, a process of scoping is in place. This is based on annual calls, which typically lead to the identification of four to five ideas per cycle. Those funded receive a maximum of four years' funding of 0.5-5 million GPB, and some of these may develop into new infrastructure proposals.

The initial roadmap activities were assessed by the Technopolis Group. The ensuing report from 2023 'Process Evaluation of the UK Research & Innovation Infrastructure Programme' concluded that the initial roadmap activities were successfully delivered, with positive feedback from across all stakeholders on the approach taken and the outputs produced at the end of the process. A revision of the roadmap is under way and will be completed during the first half of 2025.

1.6.2 Funding

Between 2015/2016 and 2020/2021, the Department for Business, Energy and Industrial Strategy (BEIS) and UK Research and Innovation have spent over 7.5 billion GBP of capital funding on research and innovation infrastructure.

UKRI now arranges infrastructure funding calls every 2 years. The funding targets those infrastructure areas identified in the roadmap. The calls are organised through the research councils. The funding varies between more than 20 million – 0.5 billion GBP per major infrastructure, and in addition the councils handle discipline-specific infrastructure applications of less than 20 million GBP. There are no absolute requirements for matching funding, but in some cases the RIs may have very large contributions from universities.

The applications are evaluated by an external independent committee. The final funding decision considers the formation of a balanced portfolio for disciplinary areas, funding spread across the country, support of pure versus practical research, and international versus national needs.

Funding is also provided by charities, such as the Wellcome Trust, and the national health care system, but exact data on their contribution is not included in the roadmap. The non-governmental funding is largely separated from the governmental funding, but some co-funding may occur. Moreover, industry users can make contributions to some infrastructures primarily in the form of joint campuses.

It is stated that the government has positioned research and development at the heart of the industrial strategy. At local level, co-operation between geographically close RI infrastructures and businesses can enhance innovation and partnerships. At national level, the emphasis is on investing in strategic infrastructure networks and forging better linkages between existing infrastructures. International collaboration enables research and innovation on a scale beyond a single country. UK has always been a key contributor to European infrastructures, and their funding has not changed. UK has remained a member of the ERICs, and it is now waiting for associate status so that it can fully engage in new ESFRI developments.

1.7 The United States of America

1.7.1 Strategy for funding and structure of the funding system

The National Science and Technology Council (NSTC) is the principal means by which the executive branch coordinates science and technology policy across the diverse entities that make up federal research and development enterprise. NSTC´s subcommittee on Research and Development Infrastructure (RDI) coordinates federal investments in infrastructure across the nation. The Office of Science and Technology Policy (OSTP) provides the President with advice on scientific, engineering, and technological aspects. The report “National Strategic Overview for Research and Development Infrastructure”, published in October 2021, provide a strategic vision that presents key policy opportunities to optimise federal Research and Development Infrastructure RDI investments and planning over the next 20 years. In the report, 14 federal agencies (including the Department of Energy, the National Institute of Health, and the National Aeronautics and Space Administration) of the NSTC subcommittee on RDI outlined the role of RDIs in supporting their R&D communities and missions. New strategy reports are typically produced in association with changes in the government.

The 2021 Strategic Overview provides a high-level landscape of federally supported RDI in national priority areas. It aims to identify gaps and opportunities that could benefit from new or improved interagency coordination and/or partnerships both nationally and internationally. It also outlines policy or coordination objectives in critical and emerging priority areas to address near-term (5-10 years) and emergent future needs, considering long-term sustainability for R&D infrastructure investments (40 years or more). The scope is limited to federally supported RDIs.

The capabilities provided by the RDIs have historically bolstered US’s leadership position in the global research and development enterprise. However, the US position as a global leader in development and advancement of new industries and disciplines is increasingly challenged by competition from other nations.

The 2021 Strategic Overview outlines two broad classes of RDI: 1) RDIs that directly support research in areas that have direct bearing on economic competitiveness, national security, and public health, and 2) those facilities that support research into purely discovery-oriented science.

The Report describes four key policy opportunities:

- Maintaining strong and integrated R&D&I planning and coordination; OSTP works closely with federal agencies through the NSTC to coordinate priorities, including the National Nanotechnology Office and R&D&I for COVID-19 research.
- Ensuring R&D&Is support a flexible and agile R&D enterprise; mechanisms to seek input from R&D communities, such as decadal surveys setting a broad vision for science, including the infrastructure and research capabilities needed, and carried out by the National Academies, federal advisory committees and research communities, and workshops, for example to inform cybersecurity infrastructure; identifying emerging areas, such as the development of the National Quantum Initiative; big-data applications and sharing of very large datasets; considerations for R&D&I lifecycle, including modernising, repurposing or decommissioning; retaining the best and brightest in R&D careers. An example of the decadal surveys is the report “Facilities for the Future of Science – A Twenty-Year Outlook” published by the US Department of Energy in November 2003, which outlines many of the nation’s most advanced large-scale research and development user facilities. These facilities are located at national laboratories and universities around the country. A new survey is currently under development.
- Advancing R&D&I capabilities to support the convergence of disciplines and sectors; transformative R&D emerges at the boundaries of traditional disciplines, such as nanoscience, AI, quantum information science and between the biological and physical sciences; examples of convergence include brain research and synchrotron technologies.
- Balancing R&D&I openness with security needs; maintaining an open and internationally collaborative nature of R&D balanced with national security concerns and economic interests, including international IPR coordination and collaboration, and international collaboration for global earth observation, etc.

The Report notes a paradigm shift, a drastic change within recent decades enabling science to become more networked, flexible and reconfigured. The focus on “Big Science” consisting of large-scale, stand-alone and discipline-specific RIs is in the 21st century evolving to the use of multiple RIs as a networked enterprise of experimental and observational RI, knowledge RI, and research cyberinfrastructure.

A complete portfolio of the infrastructures is not provided. Instead, six areas that highlight the significance of the nation’s world-class R&D&Is are presented, including several examples of infrastructures. The six areas are 1) Driving US innovation and competitiveness in leading-edge R&D, such as AI, quantum

information science, advanced communications and wireless technology, advanced manufacturing, and biotechnology; 2) Ensuring the nation's defence and resilience, including critical RI for advanced military capabilities, semiconductors, critical minerals, biological threats; 3) Understanding our planet, including the climate crisis, the Arctic and the Antarctic; 4) Supporting natural resource-based industries and ensuring food security; 5) Advancing human health and biomedical sciences, and 6) Exploring the physics of our universe.

Quantum information science is noted as the next technological revolution. As indicated in an interview with representatives from the Department of Energy, needs for new RIs are driven by scientific needs, which are supported by benchmarking capabilities and building collaborative activities, and then, if needed, followed by building new facilities.

More detailed overviews of RIs in the US are provided by the different federal agencies, such as the Department of Energy's (DOE) Office of Science, which runs ten national laboratories as well as funds RIs in many universities. In US there is a practice of preparing long-term 20-year surveys that involve research councils in the funding organisations, HEIs, and the various national academies.

1.7.2 Funding

Altogether, the funding streams are combinations of funding of the national laboratories, universities, and research projects. Contribution of non-governmental funders can be made in some cases but the extent to which this occurs is difficult to estimate. For example, several philanthropic organisations may contribute with funding but on an ad hoc basis.

The federal funding concentrates at the national level. Moreover, international funding occurs across various R&D&Is, where the US seeks strategic global collaboration to share R&D&I resources, costs, and expertise as dictated by disciplinary needs, for example CERN.

1.8 European Strategy Forum on Research Infrastructures (ESFRI)

ESFRI, the European Strategy Forum on Research Infrastructures, is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach. The competitive and open access to high quality RIs supports and benchmarks the quality of the activities of European scientists and attracts the best researchers from around the world. ESFRI has established a European Roadmap for RIs for the next 10-20 years.

The ESFRI Roadmap is an ongoing process. First published in 2006, with 35 projects, it was updated in 2008 bringing the number of RIs of pan-European relevance to 44. The update focusing on projects dealing with energy, food and biology was published in December 2010. The Roadmap 2016 update process identified projects that were expected to move to implementation in less than 10

years from their first inclusion on the Roadmap. Roadmap 2018 included 37 landmarks and 18 projects, while in the 2021 update a total of 63 RIs of scientific excellence were included.

The ESFRI Roadmap 2026 is in preparation. This update of the ESFRI Roadmap seeks to continue in the same direction, collaborating towards building a robust and sustainable European RI Ecosystem, bolstering the European Union's competitiveness, excellence and advancing the European Research Area.

Since 2016, ESFRI has introduced a landscape analysis in its roadmaps, providing and overview of the European RI ecosystem, identifying key RIs and their global positioning. To underline the strategic relevance of the landscape analysis, ESFRI has de-coupled it from the Roadmap. Thus, the 2024 Landscape Analysis is now a stand-alone document, that could be used by the scientific community to learn about available resources and identify their future needs. Moreover, the 2024 Landscape Analysis provides the framework and rationale for the 2026 Roadmap.

This landscape analysis includes the first version of the ESFRI RIs portfolio as an up-to-date online tool describing all ESFRI RIs. It also helps to identify potential gaps in the current landscape. For the first time, this analysis was prepared with input received directly from the main stakeholders.

The ESFRI 2024 Landscape Analysis finds European RIs at transformative crossroads marked by rapid technological advancements, evolving governance dynamics, and pressing societal challenges while facing constrained budgets. The report offers a comprehensive analysis of this dynamic environment, encapsulating current states, services, impact, future trends, challenges, and opportunities. It combines domain specific findings along the six ESFRI scientific domains (Data, Computing and Digital RIs, Energy, Environment, Health and Food, Physical Sciences and Engineering, and Social Sciences and Humanities), with broader cross-domain views.

In terms of gaps in the RI landscape, the report points to the e-infrastructures, where there is still significant potential to enhance and intensify the collaboration. According to the report, sharing competencies, tools and software development efforts can significantly reduce overlapping work. Wider utilisation of European joint resources could result in cost efficiency and potential to scale the application performance much higher. Data in various forms is considered a key asset for the future, which can be addressed through the European RI and e-infrastructure collaboration. Furthermore, the report urges to adopt a holistic approach supporting the convergent use of HPC and AI infrastructures. This requires additional interaction between the HPC and AI communities to discuss common issues. The landscape analysis also points to a myriad of opportunities for synergies across different domains in both digital infrastructure and services. Increased collaboration and information exchange between stakeholders can yield significant positive outcomes.

Two ongoing initiatives address cross-domain aspects, one being the European e-infrastructure reflection group (e-IRG) supporting coherent, innovative and strategic e-infrastructure policymaking as well as the development of convergent and sustainable e-infrastructure services. The Research Data Alliance (RDA) focuses on developing and promoting solutions, standards, and best practices for research data sharing and management. RDA is community-driven and brings together researchers, data scientists, librarians, industry representatives, and other stakeholders to address the challenges of data-driven research.

2 Processes to support a holistic understanding of the infrastructure landscape

2.1 Mapping infrastructure resources available to the research community

The **UK Roadmap** process included a parallel analysis of the RI landscape at an unprecedented scale and summarised it in an extensive report. The focus was on RIs funded through public sector research and innovation funders. A questionnaire approach and analysis identified over 750 infrastructures of regional, national, and international significance. Followed by publication of this data, over 100 additional questionnaire returns filled gaps and improved coverage. The landscape was found to be extremely diverse. 60 percent of the RIs had an expected economic life of over 25 years and 78 percent over 15 years, and the RIs employed just under 25 000 staff. Altogether, 527 responses were identified of national or international significance. Reasons behind the exclusion of questionnaire responses were presented. The next roadmap process is scheduled to include a survey targeting over 500 RIs.

As part of the **Netherlands' 2021 RI Roadmap**, an inventory of the RIs was commissioned via the boards of all universities, national research institutes, and national institutes, resulting in 146 proposals, and among these 122 fulfilled the set criteria. A landscape analysis was performed also in 2016.

In the case of **Denmark**, systematic mapping of the RIs has not been performed, but an extensive database of Danish test facilities has been set up where organisations can list their RIs.

In several other countries the proposals responding to national RI calls form a basis for identifying existing RIs and plans for new ones.

2.2 Identification of future needs of research infrastructure

National strategic priorities have been outlined for most countries. However, the identification of future needs in most countries does not rely on a clearly outlined process, albeit exceptions exist. In terms of stakeholder engagement, structured broad dialogue is often ensured by including representatives of higher education institutions (HEIs), research institutions and innovation actors in committees that decide on RI policies and funding.

Strategic priorities in **Denmark** include the co-hosting of ESS and the recent earmarked funding for a new research vessel, DANA. Moreover, the green

transition and contributions towards solutions for the major societal challenges are important ambitions.

In **Finland,** the most significant strategic RI investment is the EuroHPC, co-hosted by Finland and, at national scale, that of quantum computing. Structured dialogue with stakeholders takes place in the Finnish RI Committee with representation from parts of the HEIs and research institutes as well as through preparatory workshops and hearings.

In the **Netherlands** Roadmap 2021, researchers representing three broad domains including nine thematic clusters carried out a bottom-up process to identify RIs in need of investment over the next ten years. These nine thematic researcher groups continue to have a critical role in preparing the funding calls. Digitalisation has been targeted through a separate funding program, and a new strategic priority is joining in the Einstein telescope project.

The **Norwegian** Roadmap identifies polar, maritime and sea-food themes as areas of world-class leadership. Consequently, Norway has land-based research platforms, ice-breaking research vessels and various marine observations systems, as well as RIs at stations in the Antarctic and on Svalbard. The funding of certain RIs is decided at Government level, such as ECCSEL, CESSDA, ESS, EISCAT, the Marine Technology Centre in Trondheim and Svalbard, implying strategic prioritisation. Within the energy theme, a special topic is presented by the petroleum research and technology development.

Sweden hosts several large-scale RIs that are considered of great importance to its international visibility, namely ESS, MAX IV, EISCAT-3D and NAISS. Dialogue between the Swedish Research Council and the HEIs is organised through an infrastructure reference group.

To identify new needs, the **UK** has recently begun to employ a scoping process. This is based on annual RI funding calls, which typically lead to identification of four to five ideas per cycle. Those funded receive funding for a maximum of four years of 0.5-5 million GBP. Some of these ideas may develop into new RI proposals. The UK has importantly remained a member of the ERICs and is now waiting for opportunities to engage in new ESFRI developments.

In the **US,** the 2021 Strategic Overview of Research and Development Infrastructure by the Office advising the President provides a high-level landscape of federally supported RI in nationally critical and emerging priority areas. Preparation of the Overview involves many federal agencies, and consultation of the academies and other stakeholders. This Overview addresses near-term and emerging future needs and considers long-term sustainability of RI investments (40 years or more).

2.3 Categorisation of infrastructure as a basis for describing available resources

The **ESFRI** Landscape analysis categorises RIs in six thematic areas: 1) Data, computing and digital, 2) Energy, 3) Environment, 4) Health and food, 5) Physical sciences and engineering, and 6) Social sciences and humanities.

All European countries analysed in this report categorise their RIs in a manner resembling the ESFRI themes, albeit with some variation and adjustments to address specific national needs. In **Netherlands** and **Norway,** a model with three discipline-based themes is outlined, encompassing the technical and natural sciences, life sciences and health, and social sciences and humanities. In addition, Norway uses nine sub-domains to further refine the main themes. **Sweden** has the highest number of categories, nine, but even these correspond to themes used in other countries. In the case of **US**, examples of RIs are presented in six areas. As special categories, these include examples of RIs driving US innovation and competitiveness (such as AI and wireless technologies) and another of defence and resilience, both mirroring their strategic positioning. The other four themes in the US plan follow the discipline-based categorisation of the other countries. Moreover, besides ESFRI, e-infrastructure is represented as its own category in Finland, Sweden and the U.K In all countries, RIs are also listed in terms of international operations.

2.4 International and national research infrastructure resources

In the European countries, the ESFRI processes and roadmaps provide the national systems with a unifying model for large-scale RIs, including their operation and categorisation of the RI themes as well as future outlooks.

The ESFRI Landscape Analysis 2024 is a stand-alone document that describes the ESFRI RI portfolio and identifies critical gaps in the current landscape. It also includes a trend analysis on the evolving dynamics of the European RIs. Without doubt, this Europe-wide effort is highly useful for considering the RI policies and developments in the European countries.

It is also noteworthy that participation in the ESFRI RIs often involves national representatives from a relevant ministry and from the scientific user community. This facilitates building an understanding of the significance of international and national RIs that is shared between the funders and the RI users.

Examples of recent major roles played by ESFRI include better recognition of the emerging RI needs in social sciences and humanities. Another example is the e-infrastructure development and needs for digital services including networking, computing and data management, and fostering open science.

In all European countries, strong participation in ESFRI and ERIC RIs has been prioritised throughout the various thematic RI areas. This typically includes

hosting of some of the ESFRI/ERIC RIs, serving as national nodes, or being a partner in many RIs. Active engagement in the ESFRI development processes is evident.

Access to international RIs is critical to high-level research in many fields, and thus the international visibility of the country's research. Here one can consider the different types of RIs: single-site facilities such as accelerators and synchrotrons, or distributed RIs such as various datasets and archives. In both cases, researchers benefit from access to the international RIs and the networks formed in association with the RIs. As stated in some of the national roadmaps, it is important to build a continuum from local to national to international RIs.

In view of the strong participation in international RIs, discussions about the membership fees paid by the countries are common and often set against national RI needs. Several countries have assessed the returns of their international RI participation in efforts to secure greater benefits from such co-operations. For example, Denmark considers itself among the most able to exploit the opportunities that the memberships offer. However, most countries lack strategies and action plans to exploit the memberships.

In terms of the significance of RIs on innovation and businesses, better involvement in developing roles as well as users is called for. However, structured measures to support companies' interaction with RIs are also in place in some countries, such as BigScience.dk and BiSS in Sweden.

3 Processes for prioritisation of research infrastructure

The need for research infrastructures is increasing across all disciplines but the resources to fund infrastructures do not increase at the same rate. Research within many fields is addressing scientific questions that demand highly advanced and specialised instrumentation. At the same time, demand for infrastructure is growing within fields that traditionally have not had extensive users, primarily within social science and humanities. Therefore, the needs and expectations to prioritise the available funding in the most efficient way are increasing.

A comprehensive understanding of the infrastructure landscape, that is, the state-of-the-art and the needs, as described in chapter 2, has the potential to constitute a basis for a transparent and strategic prioritisation of funding for infrastructure.

Again, stakeholder dialogues are foreseen as an important tool in identifying common priorities in the national research system. This is also necessary to plan co-funding and long-term operation of RIs.

3.1 Identification of strategic priorities

Generally, the criteria for national RIs are very similar for each country, including promotion of high-quality science, wide impact in the scientific community and in society as a whole, provision of skilled services, and open access. In most countries, international evaluations are used to assess the applications submitted.

Landscape efforts and RI surveys often has a broad approach targeting stakeholders in academia as well as both public and private actors, such as university hospitals and relevant businesses. RI councils typically include representation from different communities and scientific fields.

In some cases, strategic priorities for funding reflect priorities decided at political/governmental level. Typically, these include international RI memberships, such as for CERN, ESA and others. In many cases, strategic priorities are an outcome of various international discussions and forecasting processes supported by the research community and linked to the country´s economic growth plans. The transition towards digitalisation and greening is strongly advocated at EU level. Not surprisingly, in recent years funding for digitalisation and e-infrastructures has become a strategic priority in all countries. Other examples are AI, quantum computing, and wireless connectivity. Also, a strong push from the scientific community often draws attention to new development needs.

Specific priorities have also been identified reflecting national R&D policies determined at governmental level, such as marine and Arctic research in Norway, high-end physics in Sweden, quantum computing in Finland, a new research vessel in Denmark, and a plan to join a very large-scale international telescope project in Netherlands.

An example of a comprehensive prioritisation process is the development of Netherlands' 2021 Roadmap structured around nine thematic areas, each represented by a researcher-based group. A bottom-up process is used, where the researcher groups identified the most important RIs for each theme and were responsible for describing the theme in the roadmap document. These groups were also tasked with prioritising the RI plans most in need of investment. The groups continue to play a role in planning the RI calls. The funding allocations for domains have been set at 45 percent to technical and natural sciences, 45 percent to life and medical sciences, and 10 percent to social sciences and humanities.

3.2 Balancing ongoing versus new funding commitments

In prioritisation, a balance between continued funding for ongoing commitments and funding for new commitments is important, as well as a balance between different research areas. The different funding systems tend to reserve a smaller amount of their RI funding for new commitments.

In Finland, RI applications have been sorted into two groups: those included in the roadmap, and those that are not. A few of the latter group of RI applications have usually been funded through competitive calls, although most of the funding has been used for the roadmap RI applications. Nevertheless, the off-roadmap category of RI applications has been highly popular, signifying greater needs for RI funding than budgets allow. A well-structured approach for identifying new needs is the process of scoping recently introduced in the UK.

3.3 Prioritisation based on a portfolio approach

In Denmark a portfolio of sixteen new and significant upgrades was formed, based on a larger number of proposals received and subsequently evaluated by an international panel. All fields were included in the portfolio.

The 2024 call for Finland's upcoming roadmap for national RIs during the years 2025-2028 has identified a portfolio of 21 RIs, and those proposals that perform best in the evaluation process will be upgraded to "lighthouse infrastructures".

In Netherlands, the thematically identified RIs are prioritised for funding using the researcher-based groups and their assessment of the most urgent funding needs.

3.4 Balancing commitments in national infrastructures versus access to international infrastructures

It is recognised that RIs often form a jigsaw puzzle, where local, national and international RIs merge to form the full picture of service and access needed by the R&D communities. Thus, national RIs are often connected to international RIs, and funding at both levels is necessary. Commitments to international memberships can be for a very long duration, or in some cases taken for periods of a few years. Such contributions cannot easily be adjusted. Therefore, a balance between international commitments and national needs is necessary. Most countries have broad research interests and strong researcher communities in many fields, creating strong pressure for linking to the international RI activities. Strict or clear criteria for achieving the balance are not evident. Furthermore, the still-expanding RI spectrum does not appear to ease the dilemma.

4 Processes for funding

There are many different types of RIs, which require different types of funding measures. Memberships of large international RIs, such as CERN (with the highest membership fees in most countries), EMBL, and ESO, typically require government or parliament-level long-term (perpetual) commitments. The funding for these convention-bound RIs is typically in the form of an earmarked membership fee, but indirect contributions are also possible, and requests for more in-kind funding have been presented in some of the interviews. In some cases, universities representing the user communities are required to contribute to the fees. Another international category is formed by the ESFRI/ERIC-related RIs. The number of commitments is typically high and spread over different thematic areas presented in the ESFRI Landscape. Since the first ESFRI Roadmap in 2006, these have deeply engaged the entire European researcher body, resulting in a gamechanger for European RI planning and for researcher networking. Commitments to these RIs may also require government/parliament-level decisions. The level of membership fees varies, from small to higher amounts. These RIs may also receive competitive EU funding and, especially in the case of national nodes, their improved linking to international RIs may provide opportunities for obtaining EU funding. Altogether, the international RI commitments constitute a significant portion of countries' RI funding, from about half to two-thirds of the total RI funding. However, the evaluation of the results of these large commitments does not appear to be coherent and well-structured.

For some purposes, competitive calls for funding can be suitable. For other types of infrastructure, the funding commitment should be long-term, based on evaluations of progress and ability to adapt to how the research frontier develops. Besides the international RIs discussed above, national RIs are in many cases also of a long-term nature. In the US, examples of truly long-term commitments are represented by their many national laboratories. The long-term nature is evident in the national RI roadmaps, where the same RIs appear repeatedly and are often selected for several rounds of funding. While the need for long-term funding is well understood, policies for handling long-term needs are not very clear. The fact that such established RIs are required to apply in open RI calls on same basis as any other RI certainly fosters their development and quality, but on the other hand, it probably causes frustration both among RI providers and those deciding on their funding. Examples of nationally used RIs where the long-term funding responsibility has been taken over by their host organisation after a suitable period of national funding were not identified. This likely reflects the inadequate ability of the hosts to take full responsibility at national level.

The countries organise open RI calls on a regular basis, often biannually, and in some cases these calls are preceded by landscape analysis and inventories of RIs. The roadmaps form the basis for the funding decisions, and in those countries

where a stringent portfolio has been formed, funds can be largely targeted based on the portfolio. The cut-off levels of the regular open RI calls vary between the countries from a few million EUR per RI in most cases to about 20 million EUR, the higher levels used in Netherlands and the UK. In the case of Finland, the recent decision of reducing the number of roadmap RIs for 2025-2028 will likely lead to higher funding levels per RI compared with the previous average of 2-3 million EUR. In addition, ad-hoc programmes for targeted funding are used in all countries. These typically represent strategic decisions at government level, for example to set up new operations, such as HPC, quantum computing, or research vessels.

Depending on the type of RI, the life cycle of the infrastructure may look different, as some infrastructures are very long-term investments whereas others may have a shorter time horizon. The life cycle of an infrastructure encompasses a construction/build-up phase, an operational phase with possible updates, and decommission. The funding processes attempt to adjust to these different phases.

5 Recommendations for the development of the Swedish system of research infrastructure funding

The Swedish Research Council´s Guide to Research Infrastructure 2023 includes a summary with nine recommendations. In brief, these deal with long-term secured funding schemes, the level of support during the lifecycle of an RI, recognition of changed and new needs of RIs, career paths for those providing RI user support, ensuring the returns on international RI memberships, long-term development of the large-scale RIs in Sweden, targeting different research fields and different phases of RI´s lifecycle, financial schemes that support open accessibility to research data, and securing wide engagement by the research community in the work on the strategic agenda for RIs. These point out needs for further RI developments in Sweden but based on an assessment of RI policies and concerns in Sweden and six other countries, these points are largely pertinent to any of the countries discussed in this report.

The following recommendations are drawn from the documents and discussions on RI policies in Denmark, Finland, Netherlands, Norway, Sweden, the UK, and the USA.

Sharing of tasks - While the Swedish Research Council cannot be responsible for planning and funding everything that may arise from the recommendations, the future Swedish RI roadmap could include a holistic view coordinated by the Council of the development of scientific research in Sweden, and how the RI policies at international, national, and local level should be developed to support high-level internationally significant research. This should include considerations on Sweden´s future roles and partnerships in the European ESFRI RI services and their developments. Some of the recommendations could be carried out by the Swedish Research Council, but others should be administered by the hosts of the RIs. The research communities are the key drivers of RI needs that support their scientific endeavours. In view of the growing need to share responsibilities and expertise, the research communities should assume leading roles in making and aligning strategic choices regarding RI activities locally, nationally and internationally. Moreover, well-considered priorities and funding programmes for their RI activities are required by the host organisations. Altogether, planning the division of tasks in the future RIs in Sweden should be carried out jointly by the research community, the funding organisations, and the Higher Education Institutions' Reference Group for Research Infrastructure (URFI).

Recognition of the need for structured RI policies and funding has become increasingly evident at governmental level in the R&D policies of all countries. RIs are considered critical for maintaining scientific excellence and international

impact, as well as ensuring economic growth. In the latter case, accessibility to RIs is seen to support businesses, being especially valuable for the success of start-up companies. The recognition of the importance of RIs has led to structures and processes for planning and funding of RIs being developed, including the setting-up of specific committees responsible for RI policies and funding decisions. Furthermore, as RIs have become more expensive and more important, there is increased need for collaboration and co-operation in countries at national levels and between countries at international level.

Recommendations:

- Build a long-term vision for the roles and development of RIs to support high-level, internationally competitive research in Sweden. This entails holistic thinking of how RIs support scientific research and research-based innovation.
- Build structures for regular flow of information between researchers and other relevant stakeholders and the policy/strategy/funding organisations to ensure continuous dialogue on up-to-date RI needs at national and international levels. Given the critical role of the Swedish Research Council in Sweden, it is important that the main hosts of the national RIs are engaged in dialogue with the Council.
- Measures should be taken that highlight the benefits of the national and international RIs in supporting internationally significant scientific work, as well as economic growth and other societal impacts in Sweden. Possible methods include tasking the RIs to increase the visibility of scientific success stories for their users.
- The RIs should reach out to user communities outside the universities (the academic community) to offer their services, and assess the broader impact of the RIs, including in the business sector, by providing interesting case studies. The RIs should also increase the visibility of the use of their operations in social media and in citations from policy documents.

Addressing global challenges requires multidisciplinary and interdisciplinary co-operation by scientists representing different fields as well as participation of other societal stakeholders. RIs have emerged as the nexus for multidisciplinary research and hubs for R&D activities. There is an increasing need for co-operation across RIs, for example in biotechnology, nanotechnology, and advanced materials, in medicine from basic to clinical research, and in the transformation towards digitised humanities. RIs have become more expensive and more important, adding to the pressure for increased collaboration and cooperation. Indeed, cooperation within countries and between countries is now a necessity at national and international levels.

Recommendations:

- Facilitate networking of experimental and observational RIs as well as various types of data repositories to provide a more comprehensive support system for researchers to tackle today’s global challenges. As stated in the US report “National Strategic Overview for Research and Development

Infrastructure", published in October 2021, scientific workflow and discovery pathways depend on an integrated understanding of RIs as a networked enterprise of various types of RIs that foster the research communities.
- Build better access to the various RIs, avoid overlaps in building the RIs as well as join forces in building a shared understanding of the required e-infrastructure by forcing better connections between RIs.

A paradigm shift - There is a long tradition of cooperation and securing multinational funding of very large-scale RIs, such as accelerators and telescopes. These are typically single-site RIs, focused on 'big science' questions. While investment in and operation of these very large-scale single-site operations will continue, a drastic change, or even a paradigm shift, is taking place, from 'big science' to multiple, interconnected RIs that through distributed data sets, archives and instrumentation serve the needs of several disciplines.

Recommendation:

- Provide tailored models and understanding for very large-scale RIs (single-site and distributed) and the constantly evolving and expanding distributed RIs to address their distinct challenges in relating to funding, management and service delivery.

Systematic reviews of existing RIs and new needs within different research fields have the potential to offer comprehensive understanding of needs and how they can support the future development of research. Examples of such holistic reviews and landscaping include those performed in the UK, where RIs were mapped at local, national and international level. The US uses 20-year long-term outlooks for the future of science. However, in most countries, the RI landscape is surveyed using applications to national RI calls. The latter approach is likely to identify RIs of national and international relevance but fails to pick up emerging needs and long-term future perspectives, and also to recognise potential gaps.

Recommendations:

- Consider obtaining a holistic understanding of the state-of-the-art infrastructure landscape in Sweden and future RI perspectives. Embarking on such an endeavour is a major effort at all levels, including the Swedish Research Council, the HEIs, and other research institutions. It requires clear criteria for the types of RIs that should be included in the landscape, excluding individual instruments and data sets not linked to open access and services, or entire departments or centres.
- To avoid pitfalls when setting up large surveys, benchmarking with countries with relevant experience would be beneficial. Feedback from the UK survey, for example, indicates that no questionnaire will ever capture the totality of research and innovation infrastructures in the landscape. Some RIs may have missed out on the communications altogether. For some fields, such as social

sciences, art, and humanities, the concept of RI is recent and less embedded, risking non-participation because of a lack of self-identification.

The **level of funding needed** is highly dependent on the **different phases of the RI project** - planning, construction and operation. A perennial challenge for RIs is securing long-term funding that ensures sustainability and continuity of service provision to enable excellent research. An estimate of needs for investments, personnel and e-infrastructure should be based on careful planning of the RI. The required funding necessarily varies at the different stages, as well as the roles of the various funders involved.

Recommendations:

- Depending on the nature of the proposed RI, the planning should project the foreseeable length of operation in terms of near and mid-term (5-10-20 years ahead) and long-term, even for over 40 years. This should be combined with estimates of the different phases of operation and division of responsibility for funding at the different stages.
- The decision makers, the funders and the research community should be requested to categorise the RI applications in terms of required funding periods. In the case of evident long-term operations, this could entail granting longer funding periods for some of the RIs. This should apply not only to single-site RIs but also for some of the distributed RIs. Such funding could, for example, cover eight years with mid-term evaluation to secure funding for the latter funding period.
- Selected RIs of critical importance to the research community and of national interest could be granted special status. This is exemplified by the ESFRI Landmark RIs and the new plan for the Finnish roadmap for the years 2025-2028 that will identify a portfolio of RIs, and those proposals that perform best in the evaluation process will be upgraded to “lighthouse infrastructures”.
- Part of the user communities are well accustomed to a user fee policy. Indeed, the interest in paying for RI services is one indicator of their quality. It is advisable to expand the user fee policy to all RIs, as much as possible and at a sustainable level.

The balance of support for **existing RIs and needs of new RIs** is one of the critical issues in RI policies. High-level existing RIs are not static operations, as witnessed by needs for updating equipment, developing the expertise needed to provide up-to-date services, and extending the services to a broader range of user communities. Such needs for updates and reconfigurations of existing RIs can concern very expensive single-site RIs, such as MAX IV, but also more moderate-level needs of distributed RIs. It is widely recognised that long-term stability is essential for RIs. On the other hand, entirely new RI needs may emerge, resulting in considerations of how to fit these needs into the RI portfolio. **Geopolitical concerns** affect RI planning and strategic prioritisation and may require increased flexibility in the processes, in terms of time windows

and even considerations on dual use. Flexibility is also needed when balancing existing RIs against new needs and gaps in the existing landscape.

Recommendations:

- Clarify policies on long-term RIs and emerging RIs. The policies should embrace the 'big picture' of RI needs and recognise opportunities to merge RIs and take into account their life span, where some needs are long-term and others are 'one-off'.
- While RI portfolios set the stage for several years ahead, mechanisms for flexibility and reactivity are needed, for example through targeted calls outside the portfolio.
- Consider setting up a systematic process for the identification of new RI needs, such as the process for scoping RI needs in UK.
- Consider how to respond to possible needs for dual use RIs.

RIs are typically **categorised in terms of disciplines**, with three to six similar categories being used in different countries. For some roadmaps, the main areas are further subdivided. The RIs can also be categorised as purely discovery-oriented, or as having direct bearing on economic competitiveness, national security, and public health. The significance of RIs has grown in fields other than the traditional RI-intensive ones, for example in humanities, where examples involve data collections, repositories, and archives. Thus, the RI spectrum has broadened as the need for RIs in all scientific fields has been recognised. Moreover, RIs support the convergence of disciplines and sectors, serving the needs of new developments in scientific endeavours, and increasing and building understanding of a wider user community. The UK's policy states that the final funding decision should form a balanced portfolio for disciplinary areas, with funding spread across the country, support of pure versus applied research, and international versus national needs.

Recommendations:

- RI policies should target all research fields and pay special attention to disciplines that are less used to the concept of RIs.
- The policies should target the diversity of RIs and consider both existing RIs and new developments.
- Addressing societal challenges will require bridging the gaps between diverse disciplinary domains.
- Consider the specific needs of different fields. For example, the speed of tool development may vary between fields, being very rapid in medicine and biomedicine in particular, and the use of AI. Thus, funding should be adjusted according to the needs of the different fields.

In all fields, there is a strong trend towards **data-intensive research and digitisation**. The dramatic growth in scale and complexity of data sources supporting R&D is creating needs for cyber-RIs with advanced computing capabilities, data storage, software development, networks, and standards. The

digital transition to the “lab of the future” taps to the explosively growing data universe, and use of AI/ML in modelling, simulation and digital twinning is a gamechanger.

Recommendations:

- The digitalisation and big data revolution highlights a need for shared solutions for establishing digitalised infrastructures, with relevant computer and networking hardware and software linked to digital services and data repositories.
- While national computing and data solutions exist, there remains many unsolved issues that require coordination across disciplines to identify synergies between fields, as well as better coordination within disciplines, and in linking national services to local operations.
- This trend has also led to a growing need for data experts, which should be addressed at national level in terms of training and career models.
- AI is seen as transformative in R&D, and care should be taken to keep up with the pace of international developments in this field.

The principles of **open science** are now penetrating all activities in the scientific communities. This requires shaping the way organisations support their researchers to embrace open science in publication, data access, and operations of RIs. The European Open Science Cloud (EOSC) aims to build a European Data Space for Science. Building practical guidelines for FAIR (findable, accessible, interoperable, re-usable) sharing of data is still at an early stage.

Recommendations:

- Expenses for open science includes costs for open publishing and data storage, and the expertise needed for data management. Efficient and transparent models for sharing the costs need to be developed.
- Open access is generally a prerequisite for national and international level RIs, but it should be balanced with IPR and security needs.
- Participation in EOSC will ensure that European developments are addressed also at national level.

The growing complexity of the RI platforms increasingly necessitates growth and nurturing of **a technically proficient workforce**. This workforce is critical for maintaining excellence in R&D activities. The required specialised skills range from research technicians and technology specialists to managers and scientists. Such personnel are central to developing new technologies and methods, providing the RI services, supporting the planning of research projects and analysing data. They are more skilled than the prospective users of the open RI service and should possess a positive attitude towards helping others. However, they are often an unrecognised part of a scientific community and lacking positive career prospects. Their career paths do not align with traditional tenure track programmes.

Recommendations:

- Develop a clear and respected identity for the different personnel groups providing the RI services.
- In RIs with long-term operational modes, the personnel should be permanent and have prospects for advancing in their careers.
- Training and increasing expertise should be available to the RI personnel.

- Build co-operation between the RI users, data managers, project managers and engineers to facilitate seamless and efficient use of the opportunities provided by RIs.

In Europe, the **ESFRI** roadmaps and processes have a strong impact on national RI roadmap policies. International cooperation is seen as necessary for scientific excellence, cutting costs and as a part of the successful operation of national-level RIs. Moreover, **global collaborations** have been built to fund and operate several large-scale RIs, such as ITER developing fusion energy solutions. However, evaluation of the results of these large commitments does not appear to be coherent and well-structured.

Recommendations:

- It makes sense for small countries to be members of major international RIs and maintain broad participation reflecting their research community´s needs.
- Typically, there is an absence of strategy to exploit the memberships. Considering the returns and exploitation of international memberships should be made part of the assessment of their success.
- While researchers are eagerly participating in further building the ESFRI roadmaps, vigilance is needed in considering potential overlaps of similar RI plans. For example, instead of building a new RI, new needs could be merged with existing RIs.
- International RIs hosted by Sweden carrying high expenses, need to secure a sufficiently large and internationally recognised user base. This could involve forming networks of user communities with strong ties to the RIs, and even targeted funding programs.
- In the case of those international RIs where Sweden is a partner and carries high expenses, it is advisable to form strong and internationally visible Swedish research communities, possibly facilitated by targeted funding programmes.
- Increase the activities to obtain EU funding for supporting RIs.

Decommissioning of RIs is rarely done in the foreseeable near future of a major RI. Instead, existing RIs are constantly evolving to respond to new needs. In some cases, repurposing is done. Examples of decommissioning are rare, but one example is the ongoing decommissioning of the EISCAT radar set-up. However, essentially the same international consortium has initiated the planning and building of a new type of radar, the EISCAT_3D.

Recommendations:

- When decommissioning is done, funding is needed to dismantle existing equipment and facilities possibly combined with planned re-purposing.
- When existing RI services become outdated, the hosts and the funders should assess the operation, and either close it down or plan to repurpose the facility for more modern or entirely new activities. This may be pertinent to local RIs and to the nodes of national or international operations.

The significance of RI on **innovation and business** can be divided into "upstream" (tenders, procurement, developing roles) and "downstream" (use and research collaborations) phases. Companies can be involved in methods and technology development and, through their services, the RIs can provide benefits for the business sector. The RIs can also be seen as hubs for research, development and innovation.

Recommendations:

- To achieve greater impact and societal relevance, RIs should be encouraged to align with relevant R&D&I ecosystems that range from academic research to industry-led research.
- RIs should be encouraged to adapt to the evolving needs of their stakeholders, both in academia and other users.
- Set up co-ordination structures that facilitate stakeholder engagement involving academic players, companies and other societal players.
- RIs contribute to various stages of value chains, from basic research to applied developments and commercialisation. Especially start-ups are often dependent of access to academic RIs. However, often openly available information of the RI services and contact persons are difficult to identify for outside users (and even from inside HEIs), calling for improved access information and help in planning experiments.
- RIs in some fields require special attention to communication with policy makers and the public, for example in environmental and health fields.
- AI has become a huge opportunity for new entrepreneurial activities, linking operations that generate new scientific data with effects on data-fuelled technology of enterprises. RIs should be encouraged to take up AI-based applications of their services.

6 Literature list

Denmark

- The Danish Roadmap for Research Infrastructure 2020
- Overview of Danish test facilities

Finland

- Roadmap for Finnish Research Infrastructures 2021-2024
- Objectives and targets of the National Roadmap for Research, Development and Innovation: A new beginning for RDI cooperation between companies and research organisations, the Finnish Government, 2020
- Strategy for National Research Infrastructures in Finland, 2020-2030

Norway

- Norwegian Roadmap for Research Infrastructure 2023

The Netherlands

- The National Roadmap for Large-scale Research Infrastructure 2021
- Analysis of the Dutch participation in international research infrastructures 2023

Sweden

- The Swedish Research Council´s Guide to Research Infrastructure 2024

United Kingdom

- The UK´s Research and Innovation Infrastructure: Landscape Analysis
- The UK´s Research and Innovation Infrastructure: Opportunities to grow our capability, 2023
- Technopolis group: Process Evaluation of the UK Research & Innovation Infrastructure Programme 2023

United States of America

- National Strategic Overview for Research and Development Infrastructure, 2021
- Facilities for the Future of Science. a Twenty-Year Outlook, U.S. Department of Energy, 2003

ESFRI, European Strategic Forum of Research Infrastructure

- Roadmap & Strategy Report on Research Infrastructures, 2021
- ESFRI Landscape Analysis 2024

7 Appendices

7.1 Interview questions

The interview questions followed the instructions given by the Swedish Research Council on three topics, with an emphasis on issues not evident in the roadmap documents.

Questions on processes to support holistic understanding of the infrastructure landscape were the following:

- Are there examples of national systems that have mapped the infrastructure resources available for their research community?
- If no, are there other measures to understand and present available resources to the research community?
- How are future needs of RI identified in other national funding systems?
- Do other countries categorise their infrastructure in some way as a basis for describing the available resources? For example, thematic, related to scientific disciplines, or based on type?
- What role does ESFRI play in national systems when it comes to describing existing resources and future needs?

Questions on processes for prioritisation of RIs were the following:

- How are strategic priorities for funding of RI identified in other national systems?
- What are the elements of the process that result in identified priorities?
- How are ongoing commitments for funding prioritised against new funding commitments?
- When making priorities, is evaluation of current infrastructure commitments used as input to the process?
- Are there examples of prioritisations based on a portfolio approach?
- How is the balance between infrastructures that need to be available nationally and the need of access to international infrastructures or collaborations identified?
- How are different stakeholder groups involved in identifying strategic priorities for infrastructure?

Questions on processes for funding were the following:

- How are funding processes designed and structured in different national systems? Are there one or several processes for funding of infrastructures? Does the process/es for funding differentiate between different kinds of infrastructures?
- Are there examples of funding models where the level of funding is adapted to different phases of the infrastructure lifecycle?
- Are there requirements for co-funding and, if so, does that requirement change during the life cycle?

- What is the typical length of funding commitments?
- Are there examples of funding commitments that are based on a certain lifetime of the infrastructure that is clearly indicated from the start?
- If the governmental support to a RI is phased out, who will take on the responsibility for the RI?
- Is there any coupling of research funding with RI access?

7.2 List of interviewed persons

Denmark

- Lars Friemann Christensen, Head of Division in the Ministry of Higher Education and Science
- Bjarke Stoltze Kaspersen, Senior Advisor, the Ministry of Higher Education and Science

Finland

- Petteri Kauppinen, Senior Ministerial Adviser at the Ministry of Education, Science and Culture
- Merja Särkioja, Secretary General of the Finnish Research Infrastructure Committee, Academy of Finland (Finnish Research Council)

Norway

- Hanne Monclair, the Ministry of Education and Research
- Live Haaland, the Ministry of Education and Research
- Solveig Flock, Department Director, Research Infrastructures, The Research Council of Norway
- Kirsti Solberg Landsverk, Special Advisor, Department of Research Data and Infrastructure, The Research Council of Norway

The Netherlands

- Alice Dijkstra, Senior Programme Officer, Dutch Research Council (NOW)
- Jacqueline Mout, Ministry of Education, Culture and Science

Sweden

- Lisbeth Olsson, Secretary General for Research Infrastructure, Swedish Research Council

United Kingdom

- Chis Matthews, Head of International Research Infrastructures, Department for Science, Innovation and TechnologyClaire Devereux, UKRI Infrastructure Team

United States of America

- Linda Horton, Associate Deputy Director for Science Programs, Office of Science, Department of Energy

- Corey Cohn, Senior S&T Advisor for International Programs, Office of Science, Department of Energy
- Helen Blaine, Office of Science, Department of Energy

The results of the interviews were taken into account in the short descriptions of the overall structure of the funding system for RIs given for each country (Section 1).