NordForsk

Nordic research infrastructure collaboration

Recommendations for common Nordic activities

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Recommendations

NordForsk:

- Makes the Nordic Research Infrastructure Co-operation Committee (NRICC) a permanent committee within its organization, which, among other tasks manages funding of Nordic research infrastructure collaboration with a budget co-financed by NordForsk and the Nordic funding agencies.
- Communicates information regarding Nordic research infrastructure collaborations on their website and displays links to national lists of existing research infrastructure in each Nordic country.
- Increases the support to networking activities and support to joint Nordic research infrastructure user communities.
- Facilitates cross-border use of national unique single sited national research infrastructures by considering the perspectives of the users as well as the research infrastructure providers.
- Arranges a biannual "Nordic research infrastructure managers meeting".

The Nordic Heads of Research Councils (NORDHORCS) and its member organisations:

- Nominate the members of NRICC to the NordForsk board and give the members a complementary mandate to enable them to act on behalf of their respective organizations.
- Allocate a budget for co-financing of NordForsk research infrastructure calls, calls that should be handled by NRICC and aimed at strengthening Nordic collaboration.
- Regularly discuss joint Nordic activities related to research infrastructures.
- Encourage the national nodes of international distributed research infrastructures as well as national representatives of international single sited research infrastructures to continue and strengthen dialogues aimed at strengthening the Nordic voice in Europe.
- Consider conducting regular joint Nordic assessments of international research infrastructures.
- Discuss different degrees of coordination of the process that results in national research infrastructure roadmaps.

Contents

1. Introduction

State-of-the-art research infrastructure (RI)[1] plays a key role in enabling and developing research in most scientific domains, but they also represent an increasingly large share of the research budgets. Optimizing investments, operational costs and use of RI is therefore important and must involve national as well as international collaboration and a close dialogue between funders, RI managements and user communities.

I have been asked by NordForsk to investigate RI activities in the Nordic countries and to discuss with the Nordic Research Infrastructure Co-operation Committee (NRICC), an advisory body to the NordForsk Board, what measures can be taken to strengthen RI cooperation at the Nordic level. Nordic research cooperation clearly has a value in itself but can also help strengthening national initiatives as well as national participation in international collaborations. Cooperation on RI at the Nordic level can lead to increased availability if national infrastructures are open for cross-border usage, reduced costs if investments and operational costs are shared, a stronger voice in European initiatives, more coordinated national RI roadmaps, and finally, strengthened research and Nordic research collaboration.

Many countries have developed specific national systems for long-term planning and financing of national and international RIs, often referred to as "roadmaps". The Nordic countries all have such roadmaps in place but with some differences, for example in sharing of responsibilities for portfolio management between ministries and agencies. However, the national roadmaps are structured in a similar way, in two parts: 1) the strategic objectives for the RI policy area over the coming years ("landscape analysis") and 2) lists of specific proposals for highly prioritized RIs. A brief overview of the national systems for RIs is presented in Chapter 3 in this report.

The national cooperation is taken one step further by the well-established European cooperation on RI. The European Strategy Forum on Research Infrastructures (ESFRI) provides a process that gathers input from both the research community and the national funders and sets priorities. ESFRI, and in particular the ESFRI Roadmap, is crucial both for strengthening the impact of European research and for national research and research infrastructure strategies.

The first ESFRI roadmap was published in 2006 and most likely has been the role model for the national roadmaps of the Nordic countries. The latest published ESFRI roadmap from 2021[2] lists 41 operating RIs and 22 so called "projects"[3], RIs that are under construction. Legal forms that facilitate the establishment and operation of both single sited and distributed RIs are set up by the European Commission, in particular the European Research Infrastructure Consortium (ERIC) and Joint Undertakings (JUs). The involvement of the Nordic countries in such operations is presented and discussed below.

There is no Nordic RI roadmap. The reason is most likely that the national and European levels capture the needs for most of the strategic planning and RI cooperation. There are however several RIs that are jointly owned and/or operated by the Nordic countries using different models for cooperation and ownership: Nordic Optical Telescope, EISCAT 3D, NeIC, and the European Spallation Source for which Sweden and Denmark are host countries and majority owners.

1 For one definition see COMMISSION REGULATION (EU) No 651/2014 of 17 June 2014
2 https://roadmap2021.esfri.eu/
3 The ESFRI Projects are RIs in their preparation phase, which have been selected for the excellence of their scientific case and for their maturity, according to a sound expectation that the Project will enter the Implementation Phase within the ten-year term.

With this report I hope to be able to contribute to further common Nordic activities related to RI. The status and follow-up of some earlier recommendations and initiatives are presented in Chapter 4 together with a detailed presentation of the Nordic RI Hubs initiative from 2020. Chapter 5 presents several recommendations to NordForsk as well as to the national funding agencies and their committee NordHORCS (Nordic Heads of Research Councils).

2. Research infrastructures

According to the definition by the European Commission RI means "facilities, resources and related services that are used by the scientific community to conduct research in their respective fields and covers scientific equipment or sets of instruments, knowledge based resources such as collections, archives or structured scientific information, enabling information and communication technology-based infrastructures such as grid, computing, software and communication, or any other entity of a unique nature essential to conduct research." Consequently, RI are implemented along different organisational models, including central sources and laboratories, geographically distributed observatories or laboratories, remotely accessible resources and physical sample repositories, surveys, and longitudinal studies.

A common classification is to separate single sited and distributed RIs. This distinction is made for national as well as international RIs. The single sited RIs, i.e., facilities that have one specific location, typically have relatively high investment and operating costs and some of them would never have been built without joint national or international efforts. Distributed RIs are organised as several separate entities, jointly managed by the participating national or international partners. The main advantage with joining RIs in this way lies in the data sharing and complementarity in the equipment or the sites where the equipment is placed.

A useful reference to an effective national RI portfolio management system and the factors that RI managers should consider is presented in a report by OECD and Science Europe.[4] The report contains some guiding principles for effective national RI portfolio management system and factors that should be considered to optimising the user base of national RIs. Some of these guidelines are also applicable to the Nordic RI collaboration, for instance (for details, see the full report):

- "A management process that considers the whole portfolio of new and existing RIs together"
- "The stimulation of international networking for national RIs, and embedding international RI options alongside national RI options to find the best solutions to deliver the research requirements of the national community"
- "Appropriate means to monitor the performance of national and international RIs"
- "The provision and communication of clear and transparent mechanisms for accessing RIs, and consideration of how to extend access to new users/communities."
- "The promotion of data sharing by RI users and the establishment of appropriate mechanisms to monitor the secondary use of data generated or managed by RIs."

4 Optimising the operation and use of national RIs

It should be stressed that the user's perspective always has to be a top priority concerning RI-operations and that user communities have a very important role in this respect. In the case of distributed RIs, the users are very often closely involved in, if not identical to, the RI management. In the case of large single sited facilities there is, for obvious reasons, a clearer separation between the users and the management level. To fully account for the user's perspective it is important that the users form organised communities that have close connections to the RI management. Collaboration between researchers from the Nordic countries can play a role in this context.

3. Nordic research infrastructures management

This chapter includes short descriptions of the RI portfolio management in the Nordic countries. Links are provided to more extensive information from the respective countries. The national RIs are listed for each of the Nordic countries and the Faroe Islands in Appendix 1-6. Section 3.6 contains a short description of the memberships in international RIs from the Nordic countries. These RIs and the membership countries are listed in Appendix 7. A brief analysis of the available RIs in the Nordic countries is presented in section 3.7.

3.1 Denmark

Danish Agency for Science, Technology and Innovation appointed a permanent National Committee for Research Infrastructure in 2013. The Committee is mandated to act as a forum for preparing decision support documents and agreements on prioritisation, establishment, continuation, and financing of national and international RIs, as well as research support activities to facilitate optimal national utilisation of the RIs. The Committee is composed of representatives from the Danish universities and the Danish Council for Independent Research, with the Danish National Research Foundation as an observer.

Danish Roadmap for Research Infrastructures 2020 was published by the Danish Ministry of Higher Education and Science early 2021. The roadmap consists of two key components: the strategic objectives for the RI policy area over the coming years and a catalogue of 16 specific proposals for national infrastructures, which in the short term are recommended as investment prospects. Appendix 1 includes a list of Danish national RIs.

3.2 Finland

The Research Council of Finland is responsible for funding of national and international RIs in Finland. A Finnish Research Infrastructure Committee (FIRI Committee) was established in 2012 as a part of the Research Council of Finland. The FIRI Committee monitors and develops Finnish and international RI activities, provides funding to infrastructure projects, and monitors funded projects. The FIRI Committee comprises a broad range of representatives of Finland's public research and innovation system, universities, polytechnics, state research institutes and ministries.

The Research Council of Finland has a Strategy for National Research Infrastructures in Finland 2020–2030. Based on the strategy, the FIRI Committee, together with other actors, develop a roadmap for national and international RI activities. The present is the Roadmap for Finnish Research Infrastructures 2021–2024. Appendix 2 includes a list of Finish national RIs.

3.3 Iceland

The main public competitive fund for RIs in the fields of research and innovation is the Infrastructure Fund. The fund has since 2019 its own board and is independent from the Research Fund. It finances updates of existing infrastructures and access to domestic or foreign infrastructures as well as co-financing purchase of equipment, databases, software, and any other RI that is important for scientific progress.

The Science and Technology Policy Council commissioned the infrastructure fund to develop a research infrastructure roadmap for Iceland. The first such roadmap The Icelandic Roadmap for Research Infrastructures 2021 was published in June 2021. Appendix 3 includes a list of Icelandic national RIs.

3.4 Norway

The Research Council of Norway is responsible for the national RI funding. In 2009, the Council established the National Funding Initiative for Research Infrastructures (INFRASTRUKTUR) which allocates funding to national RIs. INFRASTRUKTUR seeks to build up relevant, up-to-date infrastructure that is accessible to the Norwegian research community and trade and industry based on the strategic decisions of the Research Council.

The Ministry of Education and Research has given the Research Council of Norway responsibility for preparing a Norwegian roadmap for investments in research infrastructure. The roadmap is intended to highlight the need for both new research infrastructures and infrastructures that have received funding from the research council. The most recent Norwegian Roadmap for Research Infrastructure was published in September 2023. The research council recently opened a new call for funding of RI of national importance. Appendix 4 includes a list of Norwegian national RIs which might be subject to changes after the funding decisions following this call.

3.5 Sweden

The Swedish Research Council (SRC) established a committee for RI in 2005. In the Research and Innovation bill 2008 the government gave SRC a national responsibility for RI and the committee changed into the Council for Research Infrastructure (RFI). RFI has thirteen members with competence within RIs from several different fields. There is no representation from the universities in RFI, instead there is a reference group with representations from the larger universities which meet regularly with representatives from RFI.

The Swedish Research Council's guide to research infrastructure 2023 (so far only available in Swedish) is a plan to Sweden's long-term need for national and international RI. It provides documentation for discussions about funding future infrastructures within the Swedish Research Council, but also in consultation with other research funding bodies nationally and internationally. An inventory and prioritisation of the needs is performed every second year. The needs inventory lists RIs that are eligible for submitting proposals to RFI. The latest version of this inventory is the Needs inventory of research infrastructure of national interest 2021/2022. Appendix 5 includes a list of Swedish national RIs.

3.6 Nordic contributions to international research infrastructures

Appendix 7 shows the partnerships from Nordic countries in international RIs. The Nordic countries are very well represented in the European RI landscape, both by their respective national node contributions to distributed RIs and as of members in single sited RIs. It should also be noted that the distributed RIs completely dominate the ESFRI Roadmap except for physics where many scientific questions require extremely advanced, and expensive, tools to preform state of the art investigations. The costs for distributed RIs are in most cases dominated by in kind contributions, i.e., national nodes in a distributed RI cover their own costs. In contrast, single sited infrastructures require large cash contributions from the members, which means that decision-making assemblies for these infrastructures must agree on budgets and plans for how the infrastructure should be developed. Such research infrastructures are long-term, which means that the costs extend over several decades and are also subject to decisions that are difficult for an individual country to control. Nordic co-operation can play an important role for both distributed and individual RIs, as will be elaborated in more detail below.

3.7 Analysis

The Nordic countries have large similarities in their respective RI portfolios, but also some evident differences (see Appendix 1-5). Since the lists are limited to national funding, some of the differences can be attributed to the fact the funding is handled in different ways in the different countries. The Danish list is shorter than the lists from countries of comparable size (Norway and Finland), which reflects the fact that in the Danish system, the universities have a larger responsibility for national RIs. For example, the Danish e-infrastructure Consortium (DeiC) is funded and co-owned by the Danish universities and the Ministry of Higher Education and Science and is not subject to competitive national funding. The Norwegian RI Roadmap has a greater industrial focus compared to the other Nordic countries which explains the comparatively extensive Norwegian RI list. This is a consequence of the broader role of the Research Council of Norway compared to the research funding agencies in the other Nordic countries.

The distribution of RIs between the five research categories (e-Infrastructure; Energy, Climate and Environment; Life Science, Biotech and Health; Physical Sciences and Engineering; Social Sciences and Humanities) also reflects the research profiles of the countries. It is interesting to note, in particular from the list showing memberships in international RIs, that the Nordic countries have a lot in common in that respect. This has led to extensive collaboration both at council level and between researchers, but there are definitely opportunities for further both deepened and broadened collaborations in several areas.

Some interesting differences in the RI profiles can also be noted. Norway has a stronger emphasis on energy than the other Nordic countries even though some of the RIs that are listed in the category "energy, climate, and environment also belong to the "engineering" category. Finland has a strong focus on e-infrastructure and climate and environment in their RI portfolio and is also very active as host for European infrastructure consortia. Sweden's portfolio is broad which is expected from a, in a Nordic context, large country. Physical sciences have a particularly strong presence in their RI profile, with ESS and Max IV as examples of big investments in single sited RIs.

The observed differences could be a motivation for Nordic collaboration. For instance, small research communities in one Nordic country, which cannot motivate investment in a national RI, could instead approach anther Nordic country which has made such investments. Also, the Norwegian example of a larger industrial involvement in RIs could be of interest also for other Nordic countries.

4. Nordic added value in research infrastructure collaboration

NordForsk and NORDHORCS play a key role in supporting joint Nordic research initiatives of high scientific quality and with a strong Nordic added value. The support role also includes RI collaboration, for which the Nordic added value is similar to that of research[5] but to a larger extent builds on long term trust and collaboration experience between researchers as well as RI leadership. Nordic added value in the case of RI cooperation includes, e.g., co-financing to reduce costs, cross-border usage which improves the availability, cooperation to formulate a stronger Nordic voice in international RI cooperations, and possibly also to get the maximum out of future investments by coordinating national RI roadmaps. In addition to activities that are directly related to the RIs, there is also a substantial collaboration between researchers using the infrastructure facilities, activities such as courses and training, which helps in establishing Nordic networks between early career researchers, and conferences and exchange of knowledge related to the usage of specific RIs.

It is clear from my discussions with RI representatives from national funding agencies, RI leaderships and user communities that there is a strong belief in Nordic cooperation. This is shown by the extensive existing RI cooperation. Examples of such on-going activities are presented below with the aim of serving as a background to discussions on to what extent NordForsk and NORDHORCS could stimulate further RI cooperation.

4.1 Follow up of NRIN recommendations

The NORIA-net "Nordic Research Infrastructures Network" (NRIN) was launched in 2009 with the aim of strengthening Nordic cooperation on RI. NRIN's work resulted for example in the report "Enhancing Nordic Research Infrastructure Cooperation" which was published 2012. The report presented eight recommendations concerning Nordic cooperation, many of them which concerned international RIs. During the ten years since the report was presented, NordForsk as well as other stakeholders have actively followed these recommendations which has led to a very positive development of Nordic RI-cooperation. Some examples are given in the comments below:

1. **National engagements in ESFRI projects of common strategic priority in the Nordics should be coordinated.**

   Comment: Today there are 33 international RIs that have at least three Nordic countries as members, 24 of them are ESFRI "Landmarks" (see Appendix 7). The network calls that NordForsk has had over the years have yielded results. Several of those who received earlier NordForsk funding as well as some of those that currently have support from the Nordic RI Hubs initiative (see below) are such networks that exist at the Nordic level. Concerning the future, there are two ESFRI "projects", the European Brain Research Infrastructures (EBRAINS) and the Generations and Gender Programme (GGP), with large interest from the Nordic countries (Denmark, Norway, Sweden in both cases).

2. **The Nordic countries should identify and possibly remove legal barriers to the cross-border sharing of data.**

   Comment: A NORIA-Net on Registers and Biobanks existed from 2011 until 2014. The report Joint Nordic Registers and Biobanks - A goldmine for health and welfare research summarizes the output from this venture. Several other initiatives have been initiated

5 https://www.norden.org/en/publication/rethinking-nordic-added-value-research

during the last ten years aiming to increase the use of sensitive data across Nordic borders, for example the Nordic Commons, a project with the aim of testing solutions and practical approaches to sharing health data between regional and national actors in the Nordic countries.[6] One observation made after contacts with researchers dependent on data from other Nordic countries is that the different national interpretation of the General Data Protection Regulation (GDPR) has introduced some limitations to data sharing and Nordic research collaboration. Presently the European Health Data Space (EHDS) regulation that aims to facilitate health data sharing at the European level is being negotiated which will have impact on secondary use of health data.

3. **Increase Nordic information exchange and coordination of administrative participation in international RI meetings.**

   Comment: There are several examples of such coordination, some of them formalized (see Appendix 7) but in many cases informal and due to the fact that Nordic researchers know each other. It lies outside my assignment to make a complete survey of Nordic collaborations related to the international RIs. However, to learn more about how such collaborations work in practice I have been in contact with users of a few of them, both single sited and distributed RIs, which are known to have an established Nordic research community. It is evident from these contacts that the user communities play an important role for Nordic collaboration. This kind of "bottom-up" approach, to stimulate contacts between research communities in the Nordic countries, is therefore strongly recommended as a general tool to strengthen collaboration focused around RIs.

4. **International memberships in RI organizations should be evaluated at the Nordic level.**

   Comment: The four Nordic countries Denmark, Finland, Norway and Sweden are members of the ESRF through the consortium Nordsync. NRIN initiated an evaluation of Nordsync and the Nordic membership of the ESRF which was published 2012. NordForsk also performed an analysis of EMBL from a Nordic perspective which was followed up by a study made by Technopolis.[7] The Swedish Research Council performed two studies: "Survey of Swedish Research Council memberships in international research infrastructure organisations" from 2018, and "National benefits from Swedish membership of international research infrastructures 2016-2019" published in 2021. In the latter case the data collection was performed together with the Research Council of Finland and the Dutch Research Council and also involved discussion with the other Nordic countries.

5. **Joint Nordic partnerships in RIs should be considered for new RI involvements at the international, European and/or regional levels.**

   Comment: There are a few examples of RIs that have been established after the NRIN report was published. The partnership between Sweden and Denmark as host nations for the European Spallation Source (ESS) ERIC has deepened over the past ten years. EISCAT 3D has been operated by EISCAT Scientific Association which is a registered organization in Sweden as well as in Norway and Finland. The ownership of Nordic Optical Telescope has changed from a Swedish foundation into university co-ownership between the Aarhus University and the University of Turku with several other universities in the Nordic region as partners. The Nordic e-Infrastructure Collaboration, NeIC, is hosted by NordForsk with partners from all the Nordic countries and Estonia.

6 Nordic biobanks and registers, a basis for innovative research on health and welfare.
7 A Nordic perspective on EMBL

Concerning "landmark" RI at the ESFRI roadmap, in addition to the Swedish/Danish ESS facility and EISCAT 3D, for which Sweden is the host, Finland has a central role in Euro-HPC JU and acts as host for ACTRIS ERIC, EUROBIOIMAGING ERIC and ICOS ERIC. Norway is the host nation for ECCSEL ERIC and CESSDA ERIC and for SIOS. As mentioned above, there are only two ESFRI "projects" with more than one Nordic country listed as prospective member, EBRAINS and GGP.

6. **NordForsk should continue to fund joint use of national RIs in the Nordic countries.**

   Comment: NordForsk has had two RI related calls in response to this recommendation. Nordic Networks on RI in 2014, and in 2020 the call for Nordic Research Infrastructure Hubs. The first call resulted in 12 funded networks. The main aim was for the networks to become a Nordic platform, thereby facilitating more coordinated Nordic participation in international RI projects. The Nordic RI Hubs were aimed at strengthening international competitiveness and facilitate the development of world-leading Nordic RI environments. Seven such hubs have received support from NordForsk. Among those are Nordic EPOS - A FAIR Nordic EPOS Data Hub, Nordic EMBL Partnership Hub for Molecular Medicine, and Bridging Nordic Microscopy Infrastructures, BNMI directly related to European RIs whereas the remaining four have the character of joint effort between national RIs. A more detailed presentation of the Hubs is given in Section 4.2.

   The Joint Nordic Neutron Research Initiative, which was launched by NordForsk in 2015, had the objectives to increase the number of Nordic-region researchers skilled at utilising neutrons in scientific analysis, as well as raise the competency level regarding neutron scattering, particularly among younger researchers and other groups without extensive experience in this field. The programme is designed to support long-term use of ESS among the Nordic countries.

7. **The Nordic countries should continue to strengthen the coordination of activities relating to RIs. NRIN believes this should be achieved by continuing the networking activities developed under the NRIN project. However, rather than prolonging the current NRIN NORIA-net, a new group should be put together with a mandate from the national funders.**

   Comment: The High-level Group on Research Infrastructures appointed by NordForsk had a four-year mandate from 2013 until 2016 and acted as strategic advisor to NordForsk on research infrastructure cooperation activities and policy-related issues. The Nordic Research Infrastructure Co-operation Committee (NRICC) was appointed by NordForsk in 2016. NRICC serves in an advisory capacity to the NordForsk Board on issues relating to research infrastructure. Its primary objective is to support joint Nordic RI efforts and to highlight the potential Nordic added value inherent in such collaboration. The committee's activities include examining Nordic funding mechanisms for research infrastructure; ways to expand the use of, and access to, research infrastructure across national borders; and, ultimately, how to strengthen international cooperation.

8. **The possibility of establishing joint Nordic e-Infrastructure platforms for data-intensive distributed RIs should be explored, particularly those which would be linked to one or more ESFRI projects. The environmental projects ICOS, LIFEWATCH and EPOS and the biomedical projects ELIXIR and BBMRI should be given priority.**

   Comment: Ongoing Nordic collaborations can be found in most of the above-mentioned RIs, in many cases they have or have received financial support from NordForsk. All Nordic countries, Finland in particular, contribute to the Euro-HPC Joint Undertaking. NeIC coordinates the Nordic WLCG TIER-1 facility, the Nordic-Baltic FAIR data forum, and the Nordic Microdata Database project.

4.2 Nordic Research Infrastructure Hubs

The overall objective of the NordForsk call for Nordic Research Infrastructure Hubs was to: "strengthen international competitiveness and facilitate the development of world-leading Nordic RI environments. The initiative allows Nordic universities, university colleges and universities of applied sciences to use Nordic cross-border cooperation as a tool for achieving their own strategic objectives, thereby building long-term institutional capacity." NordForsk received 33 applications in response to the call for and was able to fund seven of them with a budget up to 2,5 million NOK. The funding period is from 2020 until 2023. Most hubs had a delayed start due to the pandemic.

These funded infrastructure hubs are:

- Nordic EMBL Partnership Hub for Molecular Medicine
  Project leader: Poul Nissen, Aarhus University
- The Nordic Optical Telescope (NOT) Science Centre
  Project leader: Hans Kjeldsen, Aarhus University
- Nordic EPOS - A FAIR Nordic EPOS Data Hub
  Project leader: Annakaisa Korja, University of Helsinki
- Nordic MEG Hub: Collaboration of all Nordic magnetoencephalography infrastructures on education, management, and dissemination
  Project leader: Tiina Parviainen, University of Jyväskylä
- Bridging Nordic Microscopy Infrastructures, BNMI
  Project leader: Oddmund Bakke, University of Oslo
- Nordic Research Infrastructure Hub on Cold Climate Engineering – COLDHUB
  Project leader: Jukka Tuhkuri, Aalto University
- Nordic hub on Advanced Transmission Electron Microscopy in the Physical Sciences
  Project leader: Per Persson, Linköping University

Since this is the only ongoing funding related to RI, I decided to make a more detailed investigation regarding the call. The Hubs have submitted progress reports to NordForsk which have given me useful information related to my study. In addition to these reports, I have conducted interviews with the project leaders of all seven Nordic RI Hubs. The main issues raised for discussion with the hubs related to activities such as courses, training, and networking. Nordic conferences, mobility and cross-border use were also discussed. The main results of these discussions are summarised below.

Each Hub is different depending on which type of research being conducted and the RI belonging to the Hub. However, as far as the Nordic collaboration is concerned and how the criteria for NordForsk funding were expressed, there are also large similarities. All Hubs have a history of Nordic collaboration prior to the present NordForsk funding. Some of them have received funding from previous NordForsk networking programs. Since RIs normally operate during a long period of time, usually several decades, collaborations can hopefully continue also in the foreseeable future. This points at one of the most important aspects of Nordic collaboration, to foster contacts between the next generation of researchers and RI managers. Not surprisingly, there is a strong belief among the hubs that facilitating contacts between young researchers in the Nordic countries by organising courses and networking activities is a key activity to maintain long-term Nordic collaboration. To some extent such activities can exist without explicit funding, but it is my impression that the present funding has had substantial effect both on the quality and quantity of the activities, which also include seminars and conferences.

It is clear from the discussions that cross-border usage is rather rare in the case of distributed RIs. To some extent, this is because the equipment in each node is designed to fit the local/national needs and might therefore be less relevant for researchers from other countries which due to the same reason have their own needs mainly fulfilled. Instead, several project leaders mentioned that requests to learn from each other, for instance in the case of procurement of new equipment and operation of equipment, are more common. However, since also local RIs get more advanced and more expensive, the interest in cross-border usage might increase in the future. Ways to stimulate cross-border usage should therefore be explored. In the case of the single sited Nordic Optical Telescope (NOT), which is placed on La Palma, Canary Islands, the situation with respect to cross-border usage is of course very different from that of distributed RIs. Most observations still require the presence of the researcher at the site of the RI but NOT also offers the possibility to make observations "from home". This possibility has also opened for usage of the telescope by, for instance, high school students, a very interesting example of "open science". The RI hub COLD-HUB is somewhere in between distributed and single sited RIs. COLD-HUB offer unique laboratories (ice basin, cold rooms) and field sites (Svalbard, Greenland) which are open for cross-border usage but also with considerable costs which might limit the possibilities for researchers to make use of these facilities.

The Hubs that are part of a larger distributed European RIs (Nordic EMBL, Nordic EPOS, BNMI) express that collaboration within the framework of the Nordic RI Hubs make the Nordic members more united which gives the Nordic countries a common voice with a stronger impact on future strategies of the European RIs compared to if each country is acting on its own. Moreover, since these three Hubs build on national networks it makes them less dependent on a few individual PI's and therefore more sustainable in the context of European partnerships.

The ownership and the financing of investment and daily operational costs of the distributed RIs that are partners in the Hubs is not an issue for NordForsk, it is covered by each country in their own processes. However, in the case of NOT which is co-owned by Aarhus University and the University of Turku with a number of other Nordic universities as partners, financing is indeed an issue which NOT shares with other large single-sited RIs. The discussions with NOT have given important insights to both strengths and weaknesses of Nordic Co-ownership and partnership. This is be discussed further in Chapter 5.

4.3 Additional observations

Particle physics and CERN: In the current situation there are ongoing joint Nordic activities both related to the experiments performed at CERN and in preparation for Council and committee meetings. In the long-term perspective, it is important to maintain such activities in order for the Nordic countries to have a stronger impact on the development of CERN, in particular regarding the future expansion plans of CERN.

Geophysics, EPOS and national security: The Nordic seismic network, which is centred in Iceland, started as a project financed by the Nordic Council of Ministers. The central components (hardware and software) were designed and built within the project and became operational around 1991, has been gradually expanded, and are still used today. Today, EPOS and Nordic seismic network provide resources to support society and industry with information not only on security needs in the face of natural disasters but also on mineral exploration, geothermal energy, and man-made hazards. The relevance to national security is particularly important in the present situation of geopolitical instability.

Brain research and EBRAINS: There is a large research community in the field of neuroscience, and brain research in the Nordics. Research groups collaborate extensively within the European Flagship Human Brain Project. The Nordic MEG Hub constitutes a collaboration of all Nordic magnetoencephalography infrastructures on education, management, and dissemination funded through NordForsk's Nordic Research Infrastructure Hubs funding instrument.

EBRAINS is one of the few research infrastructures listed as "projects" on the ESFRI Roadmap 2021, which (at least) three Nordic countries have expressed interests in. Based on the strong track record of Nordic collaborations in brain research EBRAINS is indeed an opportunity for the Nordics to become a strong player in the next phase of European collaboration on brain research.

Use of national RIs across-borders: The need for advanced experimental or digital RI will most likely increase in the future. From the landscapes analysis presented above it is clear that there are several levels of RI from local, national, Nordic to the European or sometimes even global. European RIs are normally subject to cross-border usage either via partnerships using the European organizational models (ERIC and JU) but there is also a possibility to access the RI by answering call from the RIs solely based on scientific quality of the proposed usage. The actual costs for usage vary a lot depending on the type of RI and the way it is operated. Usually, the actual costs are larger in the case of single sited RIs than for distributed. Special attention should therefore be given to single sited national RIs to both make them more attractive for cross-border usage but also to help the RIs to cover the operational costs.

5. Suggestions for future Nordic RI activities

The summary of activities presented in the previous section shows that the recommendations in the report "Enhancing Nordic Research Infrastructure Cooperation" have led to considerable advancement in Nordic RI collaborations. This has been made possible due to initiatives taken by NordForsk and its committees, research funders, RI managers, and user communities. As more than ten years have passed since these recommendations were formulated, it is time to discuss and formulate new goals and set the agenda for future Nordic initiatives. The aim of this report is to help NORDHORCS and the NordForsk board to set the framework for future priorities and activities. The recommendations presented here can hopefully create Nordic added value and at the same time strengthen the national research and research infrastructure agendas.

5.1 Strengths and values

During the preparation of this report, I have met many examples of a positive attitude towards Nordic collaboration among researchers and RI managers. The most common explanations for why Nordic co-operation works so well are that it is easy to communicate and understand each other, that we live and work closely together, and that there is a long history of co-operation that is passed on to the next generation of researchers. The strategy for both research and research infrastructure collaborations should be to take advantage of these Nordic strengths. Our countries also share values such as academic freedom and trust. Nordic collaboration should therefore, to a large extent, be based on ideas and initiatives from the researchers. It is therefore important, also in the context of RI-collaborations, that funders can capture relevant research questions and provide the research community relevant support on the way forward.

5.2 Activities led by NORDHORCS

NORDHORCS is a committee consisting of the directors of the national research funding agencies in the Nordic countries with the aim to "further develop Nordic research and research policy through cooperation and knowledge exchange". It should be noted that NORDHORCS has no formal role in relation to NordForsk and is not a decision-making body in its own right.[8] Decisions regarding, for instance, co-financing of calls made by NordForsk have to be taken by each individual national funding agency. However, given that it gathers the directors of the national funders, NORDHORCS is an essential in the way it can influence and stimulate Nordic collaboration. In this capacity, and in the context of this report, it is important that NORDHORCS and NordForsk have a similar vision concerning issues related to RI and agree on the role of the national funders with respect to activities managed by NordForsk. The following recommendations (see also section 5.3 below) are aimed at....

- **NRICC:** In general, it is important to have a strong link between program committees (or similar bodies) within NordForsk and the national funding organisations. If NordForsk gives NRICC the status of a program committee (see recommendation below regarding the role of NordForsk with respect to NRICC), NORDHORCS is recommended to give the members of NRICC a complementary mandate to enable them to act on behalf of their respective organizations. NORDHORCS should nominate, to the NordForsk board, the members of the NRICC. The Nordic funding organizations are also recommended to allocate a budget for co-financing of NordForsk RI-calls, calls that should be manages by NRICC and aimed at strengthening Nordic collaboration.
- **NORDHORCS meetings:** NORDHORCS is recommended to have an annual agenda item in which each country presents its plans for national investment and membership in international RI. This item should also include discussions on the possibility of joint commitments and other issues of mutual interest related to RI. NRICC should take part in these discussions.
- **International RI:** As discussed above the costs for participation in international RIs is high and there is a common interest among the Nordic countries to ensure maximum return of investments and operational costs. NORDHORCS can encourage the national nodes of distributed RIs as well as national representatives of single sited RIs to continue with existing dialogues aimed at strengthening the influence of each Nordic country by forming Nordic alliances. NRICC can identify international RIs for which such a Nordic dialogue could be improved and assist in the process to create the necessary Nordic networks.

  Joint Nordic assessment of participation in international RIs is strongly encouraged. It has potential to save administrative costs and can, potentially, have a much stronger impact if the assessment signals that changes are necessary. Such a joint assessment can be carried out with varying degrees of cooperation. Experiences from previous collaborations should be used to design the assessment to make it as useful as possible for the national funders. If necessary, the assessment should be followed primarily by national, but also Nordic follow-up actions.

8 In the following text I try to distinguish between NordHORCS and the Nordic funding agencies. In some cases, when I refer only to NordHORCS, it means that the Directors have agreed that the organisations they represent will take certain actions.

- **Future investments in RI:** The processes for inventory of the national RI needs and strategies to fulfil these needs will most likely remain national. However, in order not to duplicate large national investments, NORDHORCS is recommended to discuss different degrees of coordination of the process that results in national RI roadmaps. Possible actions in relation to memberships in existing international RIs should be discussed based on joint assessments and coordination new initiatives such as the European Brain Research Infrastructures, EBRAINS, and the Generations and Gender Programme, GGP.

- **Common Nordic RI ownership or partnership:** The different examples of joint Nordic ownership of RIs presented above are all interesting and it is recommended that NORDHORCS take the initiative to find out which are their strengths and weaknesses. This could potentially lead to discussion of future RI candidates for joint ownership and/or partnership.

5.3 Activities led by NordForsk and NRICC:

Nordforsk has limited funding resources and should therefore not support investment- and operational costs related to RI. Instead, funding should be allocated to calls aimed at stimulating networking and collaboration. It is important to note that such funding also stimulates Nordic research collaboration, often in a very direct way since the RIs in many cased are operated by researchers. The need for RI should be kept in mind when NordForsk initiates research calls and possibly allow for costs related to (cross border) RI-usage. The three NOS-organizations should also have RI on their agendas and, when motivated, initiate contacts with NRICC (see below) to discuss matter related to RI.

- **NRICC:** The board of NordForsk is recommended to strengthen the role of NRICC in the form of a permanent committee within the NordForsk organization. In addition to the role of NRICC given by NordForsk it should also act based on the mandate given by NORDHORCS (see above). Important tasks for NRICC would be to manage funding of Nordic RI collaboration with a budget co-financed by NordForsk and the Nordic funding agencies and to exchange information regarding the development of RI in the Nordic countries and to discuss possible ways forward for joint actions. NRICC should also arrange a biannual "Nordic RI managers meeting".

- **Nordic RI visibility:** The RIs listed in Appendix 1-5 presents the nationally funded RIs in the Nordic countries. In the future, it would be desirable that each Nordic country has easily accessible and updated lists of existing RIs with information regarding the facility and contact information including a link to the RI website. Iceland is presently testing an open source software which might be useful in the context of increased visibility of the RIs. In order to extend the visibility of national RIs to cross-border visibility, NordForsk is recommended to include links to these national lists and information regarding Nordic RI collaborations on their website.

- **Nordic RI-funding:** The Nordic RI Hub funding instrument is recommended to continue and NRICC should be responsible for managing the call. It is evident from my investigations that there are many good candidates, i.e., Nordic RI networks, that could benefit greatly from such support. My recommendation is therefore to increase the support efforts but at the same time limit the funding to networking activities and support to joint Nordic user communities. The annual budget of each funded RI network can in this way be slightly reduced compared to the present support level. Since RIs exist over extended time periods it is also appropriate to extend the funding period, a five-year period is recommended. My recommendation is to increase the total budget of the program to fund about 20 such RI networks.

- **Use of national RIs across-borders:** In order to stimulate and increase cross-border RI usage between the Nordic countries there are several measures that can be taken. As discussed above, partnerships and/or co-ownership, RI networks and support to joint Nordic user communities, and efforts to make information about the facility and contact details easily accessible are all important in this context. Large and unique single sited national RIs deserve, however, special attention in this case since the operating costs of these RIs are usually higher than those of distributed RIs. To avoid payment of these costs by each user NRICC and NordHORCS are recommended to discuss this issue and to use MAX IV as an example of such an RI.

Final words

In this report I have focused on issues that can lead to Nordic added value in terms of a more effective usage of RIs and increased collaboration associated with this kind of infrastructure. I hope that the analysis and the recommendations will lead to new initiatives both by NordForsk and NORDHORCS. Needless to say, they are not meant to be implemented all at once but hopefully there is an interest in developing RI collaborations over time and that this report can serves as an inspiration not only in the near future after it has been presented.

Since RIs appear in all scientific areas, this is a large task that is hard to cover in detail by a single person. I have had the best possible assistance from NordForsk and from Maria Nilsson in particular. I have also benefitted a lot from discussions with the members of NRICC, the leaders of the Nordic RI Hubs, and several researchers with a lot of experience with RI. However, the presentation, conclusions and recommendations presented here are my own.

Linköping, November 20, 2023

Sven Stafström

Appendices

1) National research infrastructures financed by the Danish Ministry of Higher Education and Science
2) National research infrastructures financed by the Research Council of Finland
3) Infrastructures on the Islandic research infrastructure roadmap 2021
4) National research infrastructures financed by the Norwegian Research Council
5) National research infrastructures financed by the Swedish Research Council
6) Research Infrastructure in the Faroe Islands
7) Nordic participation in international RIs

Appendix 1:
National research infrastructures financed by the Danish Ministry of Higher Education and Science

ENERGY, CLIMATE AND ENVIRONMENT

ACTRIS-DK	(ACTRIS ERIC)
AnaEE	Infrastructure for experimental ecosystem research in Danmark (AnaEE ERIC)
DANA	National Research Vessel
DaSSCo	Danish System of Scientific Collections (DiSSCo)
GIOS	Greenland Integrated Observing System
ICOS/DK	Danish infrastructure for measurement of GHG in the atmosphere and their exchange with ecosystems (ICOS ERIC)
Poul la Cour Tunnel	The Danish Aerodynamic and Acoustic Wind Tunnel
ReWet	Wetland observatories for rewetting of drained peatlands
RV Aurora	Research Vessel Aurora
UAS-ability	Research infrastructure for use of drones for data collection
WINDSCANNER.DK	Mobile Facility for Wind Energy and Turbulence Research (WindScanner)
X-Power	Power Electronics Reliability Test Facilities

LIFE SCIENCE, BIOTECH AND HEALTH

	9.4T MRI rodent core
CAB	Center for Advanced Bioimaging Denmark
CACUP	Copenhagen Animal Care and Use Programme
CellX	The Danish Single Cell Examination Platform
DAMBIC	Danish Center for Molecular Biomedicinal Imaging
DAGMAR	Danish Genetically Modified Animal Resource
DBI	Danish BioImaging (EUROBIOIMAGING ERIC)
DTR	The Danish Register of Twins
DK-OPENSCREEN	Danish RI for chemical biology (EU OPENSCREEN ERIC)
DNB	Denmark's National Biobank
ELIXIR	The European Bioinformatics Infrastructure (ELIXIR ERIC)
EMBION	CryoEM research infrastructure for biological nanostructures
FOODHAY	Open Innovation FOOD and Health Laboratory
Genomic Medicine	Research infrastructure for Clinical Genomics
iNANO	The Interdisciplinary iNANO-Medicine Core Facility
	Metabolomics infrastructure
MINDLab	Core Experimental Facility for Cross-disciplinary Cognition and Communication Studies
PRO-MS	Danish National Mass Spectrometry Platform for Functional Proteomics
	A national Tissue Bank and DNA Sequencing Centre

PHYSICAL SCIENCES AND ENGINEERING

ASTRID2	The Synchrotron radiation source ASTRID2
CERN-UP	Upgrading of CERN infrastructure for experiments and computing
Danchip	National Center for Micro- and Nanofabrication
DANMAX	Danish beam line for MAX IV
	Danish Centre for Ultra-High Field NMR Spectroscopy
DanSeis	National Centre for Seismic Instrumentation
Laserlab.dk	
QUANTECH	Quantum Technology Infrastructure Proposal
SINCRYS	Single Crystal X-ray Diffraction Side-station at DanMAX

SOCIAL SCIENCES AND HUMANITIES

CLARIN-DK	Centre for Danish Language Resources and Technology infrastructures for the Humanities (CLARIN ERIC)
D-DCAF	Danish Data Center for Accounting and Finance
DIGDAG	Digital Atlas of the Danish Historical-Administrative Geography
DigHumLab	Digital Humanities Laboratory (DARIAH-EU ERIC))
DNES	Danish National Election Study
DRDS	Danish Research Data for the Social Sciences
E-RIHS.DK	Danish Research Infrastructure for Heritage Science (E-RIHS)
LARM.fm	Radio Culture and Audio Infrastructure
REGLINK-SHARE	Survey on Health, Ageing and Retirement in Europe
	Reorganization and strengthening of Danish register research
SHARE-DK	Survey on Health, Ageing and Retirement in Europe (SHARE ERIC)

Appendix 2:
National research infrastructures financed by the Research Council of Finland

E-INFRASTRUCTURE

CSC RI	IT Centre for Science
FCCI	Finnish Grid and Cloud Infrastructure
FiQCI	Finnish Quantum Computing Infrastructure
FUWIRI	Research Infrastructure for Future Wireless Communication Networks
NeIC	Nordic e-Infrastructure Collaboration
PRACE	Partnership for Advanced Computing in Europe

ENERGY, CLIMATE AND ENVIRONMENT

ACTRIS Finland	Aerosol, Clouds and Trace Gases Research Infrastructure Consortium (ACTRIS ERIC)
AnaEE Finland	Analysis and Experimentation on Ecosystems European Research Infrastructure Consortium (AnaEE ERIC)
E2S	Earth-space research ecosystem
EISCAT-3D	European Next Generation Incoherent Scatter radar
EURO-ARGO-ERIC	Euro-Argo ERIC
FinBIF	Finnish Biodiversity Information Facility, (GBIF)
FIN-EPOS	Finnish national node of the Eurpean Plate Observing System (EPOS ERIC)
FinLive RI	Finnish Livestock Research Infrastructure
FINMARI	Finnish Marine Research Infrastructure (EMBRC-ERIC)
Geoportti	The Hub for for Finnish Geospatial Research and Education Resources
HYDRO-RI-Platform	Hydrological Research Infrastructure Platform
ICOS Finland	Integrated Carbon Observation System European Research Infrastructure Consortium (ICOS ERIC)
ICDP	International Continental Scientific Drilling Programme
ICOS Finland	Integrated Carbon Observation System (ICOS ERIC)
IODP	Integrated Ocean Drilling Programme
INAR RI	Integrated Atmospheric and Earth System Science Research Infrastructure
LTER FI	Integrated European Long-Term Ecosystem, Critical Zone & Socio-Ecological Research Infrastructure (eLTER)
oGIIR	Open Geospatial Information Infrastructure for Research
Scan4est	Measuring Spatiotemporal Changes in Forest Ecosystem

LIFE SCIENCE, BIOTECH AND HEALTH

BBMRI-ERIC	European Research Infrastructure Consortium for the Biobanks and Biomolecular Resources Infrastructure
BF	Biocenter Finland
ELIXIR Finland	Finnish node of European Life-Sciences Infrastructure for Biological Information (ELIXIR ERIC)
EuroBioimaging Finland	Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences (EuroBioimaging ERIC)
EU-OPENSCREEN ERIC	European Infrastructure of Open Screening Platforms for Chemical Biology — European Research Infrastructure Consortium
EV Core	Extracellular Vesicle Core facility
FIMM	Institute for Molecular Medicine Finland (EATRIS ERIC, EMBL incl EMBC)
FINBB	Finnish Biobank Cooperative
FOODNUTRI	Climate Smart Food and Nutritition Research Infrastructure
INFRAFRONTIER Finland	BCO Transgenic and Tissue Phenotyping Core Facility (INFRAFRONTIER ERIC)
INSTRUCT Finland	INSTRUCT Center Finland, Finnish node of Integrated Structural Biology-European Research Infrastructure Consortium (INSTRUCT ERIC)
MAGICS	National Infrastructure for human virtualization and remote presence
NaPPI	National Plant Phenotyping Infrastructure
NVVL	National Virus Vector Laboratory

PHYSICAL SCIENCES AND ENGINEERING

Aalto Ice Tank	Aalto Ice Tank
ALD center Finland	Research infrastructure for atomiclayer deposition and etching
BIOECONOMY	Bioeconomy Infrastructure (IBISBA)
Casual Bee	Finnish Research Infrastructure for Characterization and Aging of Surfaces and Materials for the Local Businesses and Environmental Economy
FinnLight	Finnish National Infrastructure for Light-Based Technologies
HIM	Helium Ion Microscopy Centre
IML	Mittag-Leffler Institute
JYFL-ACCLAB	Accelerator Laboratory of the University of Jyväskylä
MAX IV	Laboratory for Synchrotron Radiation Research
NOT	Nordic Optical Telescope
OtaNano	Otaniemi research infrastructure for micro- and nanotechnologies
PII	Printed Intelligence Infrastructure
PRESI	Photonics Infrastructure for Research and Industry
RAMI	RawMatTERS Finland Infrastructure

SOCIAL SCIENCES AND HUMANITIES

ESS in Finland	The Values and opinions in Finland survey (ESS ERIC)
FIN-CLARIAH	Research Infrastructure for Social Sciences, including FIN-CLARIN and DARI-AH-FI (CLARIN ERIC, DARIAH ERIC)
FIRI-PBS	Finnish Research Infrastructure on Population Based Surveys
FIRIPO	The Finnish Research Infrastructure for Public Opinion
FSD	Finnish Social Science Data Archive (CESSDA ERIC)

Appendix 3:
Infrastructures on the Icelandic research infrastructure roadmap 2021

E-INFRASTRUCTURE

IREI	Icelandic Research e-Infrastructure

ENERGY, CLIMATE AND ENVIRONMENT

EPOS Iceland	Icelandic national node of the European Plate Observing System (EPOS ERIC)

LIFE SCIENCE, BIOTECH AND HEALTH

EFNGREIN	Chemical analysis – from atoms to biomolecules
SAMSNIÐ	From molecules to precision medicine

PHYSICAL SCIENCES AND ENGINEERING

MSE-Lab	Materials Science & Engineering Centre (Efnis-setur)

HUMANITIES

CDHA and MSHL	Centre for Digital Humanities and Arts

Appendix 4:
National research infrastructures financed by the Norwegian Research Council

E-INFRASTRUCTURE

eX3	Experimental Infrastructure for Exploration of Exascale Computing
NAIC	Norwegian Artificial Intelligence Cloud
SIGMA 2	A National e-infrastructure for Science

ENERGY, CLIMATE AND ENVIRONMENT

ACTRIS in Norway	Aerosol, Clouds, and Trace gases Research InfraStructure in Norway (ACTRIS ERIC)
Arctic ABC	Arctic ABC – Arctic Ocean ecosystems
COAT	Climate-Ecological Observatory for Arctic Tundra
ECCSEL ERIC	European Carbon Dioxide Capture and Storage Laboratory Infrastructure (EC-CSEL ERIC)
EISCAT_3D	EISCAT_3D – European Next Generation Incoherent Scatter radar
ELPOWERLAB	Future distribution and transmission electrical grid components lab
EMBRC Norway	The Norwegian Node of the European Marine Biological Resource Centre (EMBRC-ERIC)
EPOS-N	European Plate Observing System – Norway (EPOS ERIC)
The Goldschmidt Laboratory	Infrastructure for Geochronological Characterization of Solid Earth Materials
HighEFFLab	National Laboratories for an Energy Efficient Industry
HydroCen Labs	Norwegian Research Centre for Hydropower Technology Laboratories
ICOS Norway	Norway Integrated Carbon Observation System (ICOS-ERIC)
IMF	Norwegian Infrastructure for Multiphase Flows - Multiphase Labs
INES	Infrastructure for Norwegian Earth System modelling
LoVe	Lofoten-Vesterålen cabled observatory
OpenLab Drilling	OpenLab Drilling
NorPALabs	Norwegian P&A Laboratories
NABLA	Norwegian Advanced Battery Laboratory
NGTS	National Geotest sites
NMDC	Norwegian Marine Data Centre
NorArgo	A Norwegian Argo Infrastructure (Euro-Argo-ERIC)
NorBioLab	Norwegian Biorefinery Laboratory
NorBOL	Norwegian Barcode of Life Network (IboL)
NorDataNet	Norwegian Scientific Data Network
NorEMSO	The Norwegian node for the European Multidisciplinary Seafloor and water column Observatory (EMSO ERIC)
NORMAR	Norwegian Marine Robotics Facility
NorPALabs	Norwegian P&A Laboratories
NorSOOP	Norwegian Ships Of Opportunity Program for marine and atmospheric research
NSST	Norwegian laboratory for silicon-based solar cell technology
OBLO – NOWERI	Norwegian Offshore Wind Energy Research Infrastructure

ENERGY, CLIMATE AND ENVIRONMENT

SMART-H	INFRASTRUCTUR APPLICATION ON MATERIALS RESEARCH FOR TRANSPORTING HYDROGEN
	Norwegian Fuel Cell and Hydrogen Centre
SmartGrid	National Smart Grid Laboratory & Demonstration Platform
SeaBee	Norwegian Infrastructure for drone-based research, mapping and monitoring in the coastal zone
SIOS	Svalbard Integrated Artic Earth Observing System
TONe	Troll Observing Network
ULLRIGG	Ullrigg Test Centre
ZEB Lab	Norwegian Zero Emission Building Laboratory

LIFE SCIENCE, BIOTECH AND HEALTH

ATC	National Aquafeed Technology Centre
Biobank Norway	Biobank Norway – A national infrastructure for biobank (BBMRI-ERIC)
ELIXIR Norway	ELIXIR3 - Strengthening the Norwegian Node of ELIXIR
FoodPilotPlant	FoodPilotPlant at Campus Ås
NALMIN	Norwegian Advanced Light Microscopy Imaging Network
NAPI	Network of Advanced Proteomics Infrastructure
NBioC	Norwegian BioCentre – Norwegian Centre for Bioprocessing & Fermentation
NNP	Norwegian NMR (Nuclear Magnetic Resonance) Platform
NORBRAIN	Norwegian brain initiative: a large-scale infrastructure for 21st century neuroscience
NORCELlab	The NORwegian CELlulose laboratory
NorCRIN	Norwegian Clinical Research Infrastructure Network ((ECRIN-ERIC)
NORCRYST	Norwegian Macromolecular Crystallography Consortium
NorMIT	Norwegian centre for minimally invasive image guided therapy and medical technologies
NORMOLIM	Norwegian Molecular Imaging Infrastructure , (Euro-Bioimaging ERIC)
NOR-OPENSCREEN	NOR-OPENSCREEN – The Norwegian EU-OPENSCREEN node, (EU-OPENSCREEN ERIC)
NorSeq	National Consortium for Sequencing and Personalized Medicine
PCRN	The Norwegian Primary Care Research Network
PLANKTONLAB	Norwegian Center for Plankton Technology
RI SEAWEED	Norwegian Test Center for Seaweed Cultivation and Utilization Technologies

PHYSICAL SCIENCES AND ENGINEERING

ESS Lund	European Spallation Source (ESSS ERIC)
The Digital Ocean Space – Møre Ocean Lab	The Digital Ocean Space - Møre Ocean Lab
HUNT	Competence Hub for Neutron Technology
MANULAB	Norwegian Manufacturing Research Laboratory
MARINTEK	The Marine Technology Laboratories
MiMaC	Norwegian Laboratory for Mineral and Materials Characterisation
NcNeutron	Norwegian Center for Neutron Research
NORFAB	Norwegian Micro- and Nanofabrication Facility
NorLHC	Enabling LHC Physics at Extreme Collision Rates (LHC)
NORTEM	The Norwegian Centre for Transmission Electron Microscopy II
OceanLab	Ocean Space Field Laboratory Trondheimsfjorden
TEMP	Transition to Sustainable Resource Efficiency in Metal Production and Recycling

SOCIAL SCIENCES AND HUMANITIES

ACCESS	Life Course Database
ADED	Archaeological Digital Excavation Documentation
CESSDA-ERIC	Council of European Social Science Data Archives (CESSDA ERIC)
CLARINO	Common Language Resources and Technology Infrastructure (CLARIN ERIC)
	European Social Survey (ESS ERIC)
eVIR	einfrastructure for VIdeo Research
fourMs Lab	fourMs (Music, Mind, Motion, Machines)
HISTREG	Historical Registers
LIA	Language Infrastructure made Accessible
Microdata.no	Microdata Platform for Norwegian and International Research and Analysis
NORDi	Norwegian Open Research Data Infrastructure
PSI	Peace Science Infrastructure
SAMLA	National Infrastructure for Cultural History and Tradition Archives

Appendix 5:
National research infrastructures financed by the Swedish Research Council

E-INFRASTRUCTURE

Infrastruktur akronym	Uppgift
Euro HPC	European High-Performance Computing Joint Undertaking, LUMI
InfraVis	National research infrastructure for visualisation of data
NAISS	National Academic Infrastructure for Supercomputing in Sweden
PRACE	Partnership for Advanced Computing in Europe
SUNET	Swedish university data network

ENERGY, CLIMATE AND ENVIRONMENT

ACTRIS Sweden	Aerosol, Clouds, and Trace gases Research InfraStructure (ACTRIS ERIC)
EISCAT-3D	European Next Generation Incoherent Scatter Radar
EPOS-SE	Swedish node in the European Plate Observing System (EPOS ERIC)
GBIF Sweden	Swedish node in Global Biodiversity Information Facility, GBIF
ICOS Sweden	Integrated Carbon Observation System (ICOS ERIC)
NordSIMS och Vega	The Vegacenter is a microanalytical facility at the Swedish Museum of Natural History
Oden	Icebreaker Oden
Riksriggen	The Swedish drilling rigg (IODP and ICDP)
SBDI	Swedish Biodiversity Data Infrastructure
SITES	Swedish Infrastructure for Ecosystem Science

LIFE SCIENCE, BIOTECH AND HEALTH

BIS	Biobank Sweden (BBMRI-ERIC)
BioMS	National infrastructure for biological mass spectrometry
EATRIS Sweden	Swedish node of the European Infrastructure for Translational Medicine (EATRIS ERIC)
CBCS	Chemical Biology Consortium Sweden (EU-OPENSCREEN ERIC)
Clinical Studies Sweden	Clinical Studies Sweden
MIMS	The Laboratory for Molecular Infection Medicine Sweden (EMBC and EMBL)
NatMEG	The Swedish National Facility for Magnetoencephalography
NBIS	A distributed national bioinformatics infrastructure supporting life sciences in Sweden (ELIXIR ERIC)
NGI	National Genomics Infrastructure
NMI	National infrastructure for microscopy within life sciences (EuBI-ERIC)
PPS	Protein Production Sweden
RUT	Register Utiliser Tool
SIMPLER	Swedish Infrastructure for Medical Population-based Life-course and Environmental Research
STR	Swedish Twin Register
SwedNMR	Access to NMR instrumentation and expertise within biomolecular NMR, materials NMR and translational NMR.

PHYSICAL SCIENCES AND ENGINEERING

AB-ITC	Ion Technology Centre
ALICE/ATLAS/ ISOLDE	Experiments at CERN
APPA/NUSTAR/ PANDA	Atomic, Plasma Physics and Applications, Nuclear Structure, Astrophysics and Reactions, antiproton Annihilation at Darmstadt, Swedish partnerships in collaborations at FAIR
ARTEMI	National Research Infrastructure in Electron Microscopy
CEXS	Center for X-rays in Swedish Materials Science
DESIREE	Double ElectroStatic Ion Ring ExpEriment. Storage rings at Stockholm University for atomic, molecular and chemical physics.
ESS	European Spallation Source ERIC
IceCube	Neutrino Observatory
ISIS	ISIS Neutron Spallation Source. Swedish diffractometers: Polaris, HRPD and IMAT.
MAX IV	Sweden's national synchrotron light facility, the MAX IV laboratory,
MOSAIC	Instruments for Extremely large Telescope ELT(ESO)
Myfab	Swedish academic cleanroom-based nanotechnology laboratories
OSO	Onsala Space Observatory and JIVE (JIVE ERIC)
SMA – Petra III	Swedish Material Science beamline, SMS at Petra III.
SKA	Square Kilometre Array (SKAO)
SST and EST	Swedish solar telescope and European solar telescope
SuperADAM	Advanced Reflectometer for the Analysis of Materials, Swedish instrument at ILL

SOCIAL SCIENCES AND HUMANITIES

CORS	Comparative Research Center Sweden (ESS ERIC and SHARE ERIC)
DEMSCORE	Research infrastructure for Democracy, Environment, Migration, Social policy, COnflict, and REpresentation,
EUI	European University Institute
HUMINFRA	Internet-based information portal that summarises and links to digital resources.
MONA	Microdata On-Line Access
NEAR	National E-Infrastructure for Ageing Research
Nationella språkbanken and Swe-CLARIN	Nationella språkbanken and Swe-CLARIN (CLARIN ERIC)
REWHARD	RElations, Work and Health across the life-course – A Research Data infrastructure
SND	Swedish National Data Service (CESSDA ERIC)
SwedPop	Swedish population databases for research
SveDigArk	Swedish National Infrastructure for Digital Archaeology
UGU	Evaluation Through Follow-up, educational sciences

Appendix 6:
Research Infrastructure in the Faroe Islands

ENERGY, CLIMATE AND ENVIRONMENT

Jákup Sverri	National Research Vessel
ENVOFAR	Environmental data on terrestial and marine ecosystems in the Faroe Islands
GEOARKIV	Faroese Geological Survey

LIFE SCIENCE, BIOTECH AND HEALTH

FarGen	Genelogy registry, National Biobank
Birth cohorts	Birth cohorts, Department of Research, the National Hospital of the Faroe Islands

PHYSICAL SCIENCES AND ENGINEERING

iNOVA	Nationally shared Research Facilities

SOCIAL SCIENCES AND HUMANITIES

FMC	Faroese Megaword Corpus
	Archives and databases at the National Museum

Appendix 7:
Nordic participation in international RIs

List of international RIs with Nordic partners. The RIs for which there is a formalized Nordic collaboration, this collaboration is highlighted in ***italic boldface***. Nordic host countries are marked in **boldface**. Information regarding if a RI is distributed is shown in the list.
Other RIs are single sited.

E-INFRASTRUCTURE

Name&link	Full name	Type of org.	Nordic partners
NeIC	***Nordic e-Infrastructure Collaboration***	***NordForsk, distributed***	Denmark, Finland, Island, Norway, Sweden
PRACE	Partnership for Advanced Computing in Europe	ESFRI distributed	Finland, Norway, Sweden
EURO-HPC JU	The European High Performance Computing Joint Undertaking	EU JU, distributed	**Finland**, Norway, Sweden

ENERGY, CLIMATE AND ENVIRONMENT

ACTRIS	Aerosols, Clouds and Trace Gases Research Infrastructure	ESFRI, ERIC, distributed	Denmark, **Finland**, Norway, Sweden
AnaEE	Analysis and Experimentation on Ecosystems	ESFRI, ERIC, distributed	Denmark, Finland
ECCSEL	European Carbon Dioxide Capture and Storage Laboratory Infrastructure	ERIC, distributed	**Norway**
EISCAT (EISCAT-3D)	Incoherent scatter radar	ESFRI, ***EISCAT Scientific Association***	Finland, Norway, **Sweden**
EMBRC	European Marine Biological Resource Centre	ESFRI, ERIC distributed	*Finland*, Norway, Sweden
EMSO	European Multidisciplinary Seafloor and water column Observatory	ESFRI, ERIC, distributed	Norway
EPOS	European Plate Observing System ***Nordic EPOS – A FAIR Nordic EPOS Data Hub***	ESFRI, ERIC, distributed	Denmark, Finland, Island, Norway, Sweden
Euro-AGRO	Operational oceanography, part of the Agro international network	ESFRI, ERIC, distributed, international	*Denmark*, Finland, Norway
GBIF	Global Biodiversity Information Facility	International, distributed	Denmark, Finland, Island, Norway, Sweden
ICOS	Integrated Carbon Observation System	ESFRI, ERIC, distributed	Denmark, **Finland**, Norway, Sweden
ICDP	International Continental Scientific Drilling Programme	International, distributed	Finland, Island, Norway, Sweden

ENERGY, CLIMATE AND ENVIRONMENT

IODP	International Ocean Discovery Programme	International, distributed ECORD	Denmark, Finland, Norway, Sweden
ITER	International Thermonuclear Experimental Reactor	Inter-governmental, European Atomic Energy Community	Denmark, Finland, Norway, Sweden
JET	Joint European Torus	EIRO-forum UK, Euro Fusion Programme	Denmark, Finland, Sweden
JHR	Jule Horowitz Material Test Reactor	ESFRI, France	Finland, Sweden
SIOS	Svalbard Integrated Arctic Earth Observing System	International, distributed, SIOS Svalbard AS	*Finland*, **Norway**, *Sweden*

LIFE SCIENCE, BIOTECH AND HEALTH

BBMRI-ERIC	Biobanking and Biomolecular Resources Research Infrastructure	ESFRI, ERIC, distributed	Finland, Norway, Sweden
EATRIS	European Infrastructure for Translational Medicine	ESFRI, ERIC, distributed	Finland, Norway, Sweden
ECRIN	European Clinical Research Infrastructure Network	ESFRI, ERIC, distributed	Norway
ELIXIR	European Life-Sciences Infrastructure for Biological Information	ESFRI, inter-governmental, distributed	Denmark, Finland, Norway, Sweden
EMBL	European Molecular Biology Laboratory. ***The Nordic EMBL Partnership for Molecular Medicine.***	EIRO-forum, inter-governmental, distributed but with strong international nodes	Denmark, Finland, Island, Norway, Sweden
Euro-BioImaging	Research infrastructure for biological and biomedical imaging	ESFRI, ERIC, distributed	Denmark, **Finland**, Norway, Sweden
EU-OpenScreen	Research infrastructure of Open Screening Platforms for Chemical Biology	ESFRI, ERIC, distributed	Denmark, Finland, Norway, Sweden
Infrafrontier	European Research Infrastructure for Modelling Human Diseases	ESFRI, ERIC, distributed	Denmark, Finland, Sweden
Instruct	Provides open access to high-end structural biology services and techniques	ESFRI, ERIC, distributed	*Denmark*, Finland, *Sweden*

PHYSICAL SCIENCES AND ENGINEERING

CERN/LHC	European Organization for Nuclear Research, Large Hadron Collider vid CERN	*ESFRI*, EIRO-forum, inter-governmental	Denmark, Finland, Norway, Sweden
ESA	European Space Agency	EIRO-forum, Inter-governmental	Denmark, Finland, Norway, Sweden
ESO	European Southern Observatory	*ESRFI*, EIRO-forum, inter-governmental	Denmark, Finland, Sweden
ESRF	European Synchrotron Radiation Facility, ***NORDSYNC***	*ESFRI*, EIRO-forum, France	Denmark, Finland, Norway, Sweden
ESS	European Spallation Source	ESFRI, ERIC	**Denmark**, Norway, **Sweden**
EST	European Solar Telescope	ESFRI, Spain	Sweden
FAIR	Facility for Antiproton and Ion Research	ESFRI, Germany	Finland, Sweden
IceCube	Neutrino observatory	US, international	Denmark, Sweden
ILL	Institute Laue-Langevin	ESFRI, EIRO-forum, France, Germany, UK	Denmark, Sweden
ISIS	Neutron and muon source	UK	Sweden
ITER	International Thermonuclear Experimental Reactor	Inter-governmental European Atomic Energy Community	Denmark, Finland, Norway, Sweden
JIVE	Very Long Baseline Interferometry (VLBI) and other radio astronomical techniques	ERIC, distributed	Sweden
MAX IV	X-ray radiation source	**Sweden**	Denmark, Finland, Sweden
NOT	***Nordic Optical Telescope***	***Denmark, Finland***	Norway
Petra III	X-ray radiation source	Germany	Sweden
SKAO	Square Kilometre Array Observatory	ESFRI, international	Sweden
XFEL	European X-Ray Free Electron Laser Facility	ESFRI, EIRO-forum, Germany	Denmark, *Finland*, Sweden

SOCIAL SCIENCES AND HUMANITIES

CESSDA	Consortium of European Social Science Data Archives	ESFRI, ERIC, distributed	Denmark, Finland, Island **Norway**, Sweden
CLARIN	Common Language Resources and Technology Infrastructure	ESFRI, ERIC, distributed	Denmark, Finland, Island, Norway, Sweden
DARIAH	A network to enhance and support digitally enabled research and teaching across the Arts and Humanities	ESFRI, ERIC, distributed	Denmark
ESS	European Social Survey	ESFRI, ERIC, distributed	Denmark, Finland, Island, Norway, Sweden
EUI	European University Institute	Inter-governmental	Denmark, Finland, Norway, Sweden
SHARE	Survey of Health, Ageing and Retirement in Europe	ESFRI, ERIC, distributed	Denmark, Finland, Sweden

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