An outlook for the national roadmap for e-infrastructures for research

Swedish Research Council

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Foreword

The Swedish Research Council (SRC) is a public agency under the Ministry of Education and Research. The Council for Research Infrastructures (RFI) is one of the decision-making boards within the SRC responsible for policy-making, strategy development and funding of research infrastructure of national interest. The growing need for e-infrastructures - computation, analysis, storage, transfer and accessibility of data- for research is well recognized. At the same time, new requirements and demands arising from Open Science pushes the need for national alignment with international policies and good national coordination between infrastructures and e-infrastructures for research. The RFI has therefore, together with the University Reference Group for Research Infrastructures (URFI), identified that there is a need for a review to get an independent picture and advice on how to deal with the growing demands for e-infrastructures for research. As a collaborative effort, RFI and URFI initiated this review in October 2017. The objective was to receive independent advice from an expert panel for a national process to formulate a shared Swedish vision and roadmap for national e-infrastructures and the links to local, regional, and international infrastructures. The panel was chaired by Per Öster (Director, Research infrastructures and policy at CSC). Other panel members were Riitta Maijala (Vice President for Research at the Academy of Finland), Erik Fledderus (Managing Director /CEO at SURF in Netherlands), Anna Wetterbom (CEO at Sveriges Unga Akademi), Sverker Holmgren (Program Director for the Nordic e-Science Globalisation Initiative at Nordforsk, Professor in Scientific Computing at Uppsala University), and Lars Lindsköld (Portfolio-manager, SweLife/Sweper, Regional developer, Västra Götalands Regionen, adjunct lector ITIT, Gothenburg University, Sweden).

This report was submitted from the panel to the RFI and URFI in November 2018. The panel has provided concrete and useful advice to the Swedish Research Council, URFI and Swedish stakeholders in general, including the Swedish Government. I would like to extend my gratitude to the panelists for supporting this process and for their great contribution to this work. Their collective expertise and insight are truly valuable and important.

Stockholm, 15 januari 2019

Björn Halleröd
Secretary General of the Council for Research Infrastructures, Vetenskapsrådet/ Swedish Research Council

Summary

In Sweden, the current e-infrastructure landscape is relatively fragmented and many actors provide different kind of services at different levels. It is not always clear to the researcher whom to turn to for their e-infrastructure needs and what services that exist or can be developed. Decision-makers, such as e-infrastructure owners, in turn do not have clear roles and mandates in relation to each other. With new political ambitions and challenging needs expressed by research, it is key to promote coordination and collaboration among e-infrastructures in innovation, development, and provisioning of services and support. Thus, the Swedish Research Council (SRC) and the University reference group for research infrastructures (URFI) initiated this review as a collaborative effort to address these challenges. The objective of this review work is to receive independent advice from an expert panel for the national process to formulate a shared Swedish vision and roadmap for national e-infrastructures and the links to local, regional, and international infrastructures.

During the work, the panel observed that a re-occurring theme is the fragmentation of e-infrastructures and differences in ownership and funding mechanisms and the problems this causes in terms of unclear, sometimes seemingly overlapping mandates, gaps of services and confusion among e-infrastructures, universities, and also within the SRC. This is of course also a concern for researchers who use the e-infrastructures as this fragmentation risks that Swedish research is left behind. The panel has proposed eleven specific recommendations on how to continue the work for developing a coherent national strategy and roadmap for e-infrastructures for research. A specific concluding recommendation by the panel is to adopt an encompassing national e-infrastructure coordination and even consider organizational mergers of e-infrastructures. A first step in this process would be to work towards organizational interoperability among the existing e-infrastructures, including tightly connected and compatible governance structures and clear ownerships of the strategy processes. Also, the owners of the national e-infrastructures urgently need to jointly agree on the national e-infrastructure architecture[10] and the individual infrastructures tasks within this landscape. A second step would be to evaluate if the current diversity of national e-infrastructures could be reduced in terms of the number of e-infrastructure organizations. There are several models of how a unified and coherent national e-infrastructure may be organized (examples in Finland, Netherlands, Norway and Denmark). However, which type of architecture Sweden should aim for needs to be further investigated in terms of legal and cultural (i.e. what is agreed on by the HEIs and the SRC) aspects.

The proposed path towards unification is driven by several factors. The most obvious is that a more coherent organization of e-infrastructures will be better suited to serve excellent science in a cost-efficient way. Furthermore, the panel expects that, in a 5–10 year perspective the user base of e-infrastructures is going to become even more diverse and include a growing number of researchers with less experience in digital research and also researchers that are based outside of universities, e.g. in

hospitals and industry. Such users cannot be expected to navigate within a plethora of e-infrastructures and this should be another strong driver for rethinking how e-infrastructures are organized. There is a need of services to support advanced work-flows that include both national and international digital public and commercial resources. Better coordination and building a common purpose is essential if Sweden wants to be active in the European arena and influence and shape the European e-infrastructures agenda based on Swedish policies and strategies.

Sammanfattning

Det nuvarande e-infrastrukturlandskapet i Sverige är relativt fragmenterat, med många aktörer som levererar olika tjänster på olika nivåer. Det är inte alltid tydligt vart forskare ska vända sig med sina behov av e-infrastruktur, vilka tjänster som är tillgängliga, eller vilka som kan utvecklas. Beslutsfattare, exempelvis ägare av e-infrastrukturer, har i sin tur ingen tydlig rollfördelning eller mandat gentemot varandra. Med de nya politiska ambitionerna och utmaningarna från nydanande forskning behöver e-infrastrukturerna koordinera sitt arbete och samarbeta kring innovation, utveckling och tillhandahållande av tjänster och stöd. I detta syfte startade Vetenskapsrådet tillsammans med Universitetens Referensgrupp för ForskningsInfrastrukturer (URFI) denna översyn för att tillsammans adressera utmaningarna. Målet med översynen var att få återkoppling och oberoende råd av en expertpanel om den nationella processen för att formulera en gemensam vision för Sverige och en kompassriktning för nationella e-infrastrukturer och deras respektive kopplingar till lokala, regionala och internationella infrastrukturer.

Under arbetet har panelen observerat att fragmenteringen av e-infrastrukturerna och olikheterna i deras ägarskap och finansieringsmekanismer är ett återkommande tema. Detta skapar problem såsom oklarheter, överlappande mandat, luckor i e-infrastrukturtjänster samt förvirring mellan e-infrastrukturerna och universiteten och inom Vetenskapsrådet. Detta är självklart ett bekymmer för forskare som använder e-infrastrukturerna och splittringen gör att svensk forskning riskerar att släpa efter. Panelen har lämnat elva specifika rekommendationer om hur arbetet bör fortsätta för att utveckla en koherent nationell strategi och kompass för e-infrastrukturer för forskning. En särskild, slutlig rekommendation är att anamma en omfattande koordinering av de nationella e-infrastrukturerna och kanske även överväga organisatoriska sammanslagningar. Ett första steg i denna process är att arbeta mot organisatorisk interoperabilitet bland de existerande e-infrastrukturerna. Detta bör inkludera hur man skapar en stark koppling och kompatibilitet mellan respektive styrstrukturer, och ägandeskapet av strategiska processer. Ägarna av de nationella e-infrastrukturerna behöver omgående komma överens om en arkitektur för nationella e-infrastrukturer och de individuella infrastrukturernas uppgifter och ansvar inom landskapet. Nästa steg är att bedöma om nuvarande mångfald av nationella e-infrastrukturer kan reduceras i termer av antal e-infrastrukturorganisationer. Det finns flera modeller för hur en enhetlig och koherent nationell e-infrastruktur kan organiseras (exempel i Finland, Nederländerna, Norge och Danmark). Men vilken typ av arkitektur Sverige bör ha som målbild, behöver utredas i termer av legala och kulturella (dvs. bestämmelser överenskomna av SUHF och Vetenskapsrådet) aspekter.

Flera faktorer ligger bakom den föreslagna vägen mot en förening av e-infrastrukturerna. Den mest självklara är att en mer koherent organisation för e-infrastrukturer är bättre anpassad för att stödja forskning av högsta vetenskapliga kvalitet på ett kostnadseffektivt sätt. Panelen förutspår också att användarbasen för

e-infrastrukturer inom 5–10 år kommer att vara ännu mer varierad än idag och inkludera allt fler forskare med mindre erfarenhet av digital forskning och fler forskare som är aktiva utanför universiteten, t.ex. vid sjukhus och företag. Man bör inte förvänta sig att den typen av användare ska kunna navigera sig i ett överflöd av e-infrastrukturer. Detta borde vara en stark drivkraft till att fundera kring hur e-infrastrukturer är organiserade. Det finns ett behov av tjänster som stödjer avancerade arbetsflöden och som inkluderar både nationella och internationella offentliga och kommersiella digitala resurser. Bättre koordinering och utbyggnad av gemensamma syften är väsentligt om Sverige vill vara aktiv på den europeiska arenan och kunna, baserat på svensk policy och strategi, påverka och utforma den europeiska e-infrastrukturagendan.

Prelude to the report

National investigations and committee work with research stakeholders have shown for some years a rapid increase in the need for different e-infrastructures and digital services[1,2,3,4]. Researchers do not only need these services for conducting research, they and their teams also need the skills to plan and fund their research and use tools to open and publish their research as linked publications and data. This, together with digital experiments, simulations and data analysis and processing of large data sets, has put data stewardship at the core of today's research. Technological development at the research infrastructures has led to increased data resolution, meaning that research projects are producing an overall higher amount of data across the scales and across different scientific disciplines that need to be analysed and managed appropriately. Another driver of the need for e-infrastructures is the global change in research culture that comes with Open science. Open science is yet another way of practising research but based on the principle of *as open as possible and as closed as necessary*. This is believed to increase reproducibility, drive quality, improve democratisation of decision-making, transparency and have high impact on the society.

In Sweden, the current e-infrastructure landscape is relatively fragmented and many actors provide different kind of services at different levels. It is not always clear to the researcher whom to turn to for their e-infrastructure needs and what services that exist or can be developed. Decision-makers, such as e-infrastructures owners, in turn do not have clear roles and mandates in relation to each other. With new political ambitions and challenging needs expressed by research, it is key to promote coordination and collaboration among e-infrastructures in innovation, development, and provisioning of services and support. As new initiatives are also taking shape in the European landscape, a shared vision and plan would help to understand how Swedish e-infrastructures fit into the European Open Science vision and can reap from the experiences of others. Thus, the Swedish Research Council (SRC) and the University reference group for research infrastructures (URFI) initiated this review as a collaborative effort to address these challenges.

Objectives

The objective of this review work is to receive an independent advice from an expert panel for the national process to formulate a shared Swedish vision and roadmap for national e-infrastructures and the links to local, regional, and international infrastructures. The review has considered the present Swedish e-infrastructure for research, the expected future demands (next 5-10 years) of the scientific community,

[1] Swedish science cases of e-infrastructure (2014)

[2] Survey of e-infrastructure needs for eight large infrastructures (2015)

[3] International advisory review of the Swedish national infrastructure for computing (SNIC) (2017)

[4] Vetenskapsrådets guide till infrastrukutren (2018)

and opportunities for collaboration and improved coordination for more efficient use of resources and smooth seamless data workflows. The panel's report follows in the next chapter.

The review process

The SRC and the URFI set up a Working Group in October 2017 with the task to define the Terms of Reference for the review panel and suggest a list of panelists. The Working Group consisted of:

- Chair: Per Dannetun (Chair of the URFI group)
- Kristina Edström (URFI delegate)
- Lars Börjesson (URFI delegate)
- Björn Halleröd (Secretary General of Council for Research Infrastructures at SRC)
- Ingela Nyström (vice-Chair at Council for Research Infrastructures at SRC)
- Gunilla Svensson (Chair of the advisory group on e-infrastructures)
- Hanifeh Khayyeri (Senior Research Officer at SRC)

The Working Group formulated a set of key questions for the review and held in February 2018 a stakeholder hearing in order to consult them about the focus areas of the review. After the review, the focus questions and the suggested panelists were approved by both the Council for Research Infrastructures (RFI) at SRC and by the URFI group.

The panel received all documentation in April 2018 and started the review work. Two full-day panel meetings were held in Stockholm, in addition to communication via email and video meetings. For the first meeting (28-29 May 2018), the panel identified a set of stakeholders for additional interviews. The purpose of the interviews was to discuss any uncertainties and clarify aspects around the e-infrastructure's activities and strategic plans, or stakeholders' mandate and strategic plans. The second meeting (28 September 2018) allowed the panel to summarize their findings and clear and concise recommendations into a brief report. A finalized report was submitted SRC and URFI in 7 November 2018.

The expert panel

The collective competence of the panel covered strategic, organizational and technical aspects of operating, managing and funding e-infrastructures in different forms of private organizations and public sectors. The appointed panel members were:

- **Chair: Per Öster** (Director, Research Infrastructures & Policy at CSC, Finland)
- **Riitta Maijala** (Vice President for Research at the Academy of Finland, Finland)
- **Erik Fledderus** (Managing Director / CEO at SURF, The Netherlands)
- **Anna Wetterbom** (CEO at Sveriges Unga Akademi, Sweden)
- **Sverker Holmgren** (Program Director for the Nordic e-Science Globalisation Initiative at Nordforsk, Professor in Scientific Computing at Uppsala University, Sweden)

- **Lars Lindsköld** (Portfolio-manager, SweLife/Sweper, Regional developer, Västra Götalands Regionen, adjunct lector ITIT, Gothenburg University, Sweden)

The reviewers were selected based on their knowledge and expertise in the area and did not represent any organization or group of organizations. Since all group members have been working with e-infrastructures in one way or the other, a declaration of independence[5] including any conflicts of interest is provided in the Appendices for transparency.

After the review

The SRC/RFI and URFI will receive the report and discuss the conclusions and recommendations of the expert panel separately. The panel chair will be invited to present the report to URFI and RFI, in November 2018, to allow for additional discussion about the process and the outcomes. The SRC/RFI and URFI are expected to comment the recommendations in written form separately.

The SRC and URFI will host a seminar early in 2019 where they will jointly present the results of the review and their respective commitments to a broad range of stakeholders and decision makers.

Background material for the panel

The panel received activity reports and strategic plans of the following e-infrastructures for research:

- Swedish National Infrastructure for Computing (SNIC)
- Swedish National Data service (SND)
- Swedish University computer Network (SUNET)
- TILDA (metadata register and e-archiving system at the Swedish University of Agricultural Sciences)
- University libraries (a short summary provided by SUHF)
- Governmental assignment on registry-based research (a short summary and description of Registry-Utiliser-Tool (RUT))
- The panel had also access to the SRC's guide to research infrastructures and a previous report on the need for e-infrastructures in science, both from 2014. Any other additional information was also available at their request.
- The stakeholder interviews

On 28-29 May 2018, the panel held interviews with selected stakeholders to get a better understanding of the e-infrastructure landscape and the challenges that the stakeholders face. The panel interviewed the following:

- SNIC: Kristina Edström (SNIC board member) and Hans Karlsson (SNIC director)
- SND: Anders Brändström (former SND board member, mandated by current chair of SND board) and Max Petzhold (SND director)

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[5] See Appendix. This document is a modified version of one originally developed by the European Commission.

- TILDA: Kevin Bishop (vice-Chancellor of SLU and owner of TILDA) and Hanna Lindroos (Coordinator of the Data Curation Unit at SLU)
- SUHF: Astrid Söderbergh Widding (SUHF board member)
- Swedish Research Council: Sven Stafström (Director General), Maria Häll (CEO of SUNET), Maria Nilsson (Head of unit for Register-based research)
- URFI: Per Dannetun (Chair of URFI)

Deliverables from the panel

- A brief report that summarises the conclusions from the panel's assessment and includes recommendations (approx. 10 pages).
- A presentation of the final outcomes to URFI and SRC.

Key questions provided by the SRC and URFI Working Group

- Are there any gaps in the landscape, i.e. missing actors and/or services and and/or workflows and/or ensuring competence of staff? If so, please define present and/or possible risks with the gaps. *(see Recommendations 1-3,6)*
- How can one ensure that the e-infrastructure landscape will effectively serve the demands from the Swedish research community? *(see Recommendations 1-3,6)*

- Are there significant overlaps and/or complementary parts of the e-infrastructure landscape? Please comment on such areas, i.e. if they constitute a suboptimal use of resources, a potential source of conflict, or a potential for synergy, can benefit from increased cooperation. *(see Recommendation 4, 5, 8)*
  - Are there any issues with the organizational form of the different e-infrastructures? Pros and cons.
  - Are there problems or anomalies regarding the way formal responsibilities within the Swedish research system are organized? The issue involves both provision of services and ownership/responsibilities of data.
  - What is the role of private providers of services? What role can they play, should they play and, what is desirable?

- Is it possible - and desirable -to have a coherent model for funding, development and operation of e-infrastructures for research in Sweden? *(see Recommendation 7-8)*
  - How would that look (e.g. funding terms, possible co-operations etc)?
  - What would the roles and responsibilities of each actor be?
  - What would be the major steps for arriving at a more coherent and sustainable model for national e-infrastructure for research?
  - Can/Should changes of the current model be developed in phases or is a major reform the best way forward?

- Where can the national e-infrastructures be positioned in the international e-infrastructure landscape? (relationship, resource sharing, EOSC, FAIR-principles) *(see Recommendations 1-3, 10-11)*

  - Are there any specific subject-areas or national activities that would benefit from linking up to international activities or further develop usage of international e-infrastructures?
  - What are the current the current obstacles to more efficient international collaborations and what is needed to eradicate these obstacles?
- Finally, please comment on how Sweden can enable innovation and adequate evolution of e-infrastructures to make room for new fields and services to develop. *(see Recommendation 5)*

Introduction

e-Infrastructure services enable collaboration among distributed research projects and organizations and provide access to information- and communication technology (ICT) resources. Major scientific breakthroughs and innovations are increasingly achieved by analysis of data collections and performing computer simulations. This virtual mode of research has introduced new opportunities and fundamentally changed the way research and innovation is undertaken. The landscape is changing rapidly with new computer-based tools constantly emerging. Furthermore, e-infrastructure resources with new capabilities and significantly higher capacity are being made available all the time, providing novel opportunities for advancing knowledge for the benefit of research and society.

Swedish researchers have been and are at the forefront both in developing and using the latest e-infrastructures, both in scientific fields with traditionally early adopters (e.g. physics and climate research) and in areas where the use of such techniques have been less widespread (e.g. in medicine, social sciences and humanities). In recent years, the production of both scientific and other forms of digital data has increased dramatically. Because of the availability of now a multitude of data sets, a vast number of ICT-based research methods and tools is currently being developed to turn data into knowledge. With digital experiments (simulations and data analysis and processing of large data sets, digital twins) and shared international access to digital experiments is becoming a standard practise, shared e-infrastructures are playing an increasingly important role in research.

Digital experiments require a broad range of e-infrastructure services to carry out both the actual research and the increasingly important data stewardship. Data stewardship has become part of the research process as research data today is not only of interest while being actively used in a research project (operational data), but it can also be registered (assigned a persistent identifier and described by accompanying metadata) to be published, cited and be part of a data collection/bank, and even qualify for preservation. The researchers need to acquire new skills in order to manage their data appropriately to meet these demands and benefit from the opportunities of making the data behind research achievements FAIR[6].

In Europe, there is an ongoing change in culture around research data where policy makers are arguing that researchers funded with public money should make their results open and available to the public. This has led to large investments by EU member states and the European Commission to open up research data across disciplines and country borders such as, the European Open Science Cloud (EOSC) initiative. Many international infrastructures also have established, or are in the process of establishing, research data repositories, developing data management plans and advanced e-infrastructures services for their users. As a result, workflows are growing in complexity since researchers will have to manage their data both

[6]Wilkinson et al., 'The FAIR Guiding Principles for Scientific Data Management and Stewardship' (2016).

locally, nationally and internationally. Therefore, to be competitive and live up to the growing needs, strong and coherent national e-infrastructures are necessary, as also recommended by bodies like the European e-infrastructure reflections group (e-IRG).

The landscape in short

The panel identified e-infrastructures for research as "ICT-based infrastructures enabling collaborative science and innovation". This definition includes high-performance and distributed computing, storage, advanced networking, middleware services such as authentication and authorisation, and services to support research workflows, handle data and provide application software for e.g. simulations and analysis of data. e-Infrastructures also include the support staff and organizational structures required to operate them.

In Sweden, several major actors provide e-infrastructure for academic research, primarily: the Higher Educational Institutes (HEI), the Swedish Research Council (SRC), research hospitals, research institutes and commercial providers. The e-infrastructures, provided by these actors, and their governance are all important to take into account when analysing the Swedish landscape. However, in line with the instructions the panel has focused on the needs for research under the auspice of the Ministry of Education and Research[7]. Here, there are four main e-infrastructures at the national level: SND, SNIC, SUNET and RUT (see Figure 1-2). Some of these e-infrastructures are well-developed and of high quality, and others are either under development or currently in a phase of transformation.

The Higher Educational Institutions

The major responsibility to enable e-infrastructure services for academic research, in a cost-effective way, lies with the Higher Educational Institutions (HEI). In particular, since their researchers are the main consumers of the e-infrastructures for research. The Association of Swedish Higher Education Institutions (SUHF) is the main collaboration body for Swedish HEI. To facilitate collaboration specifically on research infrastructures (including e-infrastructures) the ten Swedish HEIs most active in research have formed the University reference group for research infrastructures (URFI). Some aspects related to e-infrastructures, e.g. Open Science, are also discussed in SUHF.

Many research universities have both local e-infrastructures and host nodes of distributed national e-infrastructures, e.g. SNIC centres providing computing services (HPC and HTC) and active storage facilities, and SND Data Access Units working together to coordinate and provide metadata management and research data services. The Swedish HEIs have the responsibility to manage and provide long-term storage of their research data[8], and some are already developing local e-infrastructures for storing, handling and sharing data, e.g. the TILDA system at SLU. In addition, many university libraries (and the National Library) develop and

[7] Which include the SRC and a majority of the HEIs with some exceptions such as Swedish Agricultural University (SLU)

[8] http://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/arkivlag-1990782_sfs-1990-782

operate e-infrastructure services for storage and archiving with a focus on publications. These e-infrastructures sometimes also provide services to store, open and link research data to research publications. DiVA and SwePub are two examples of such portals and most of the HEIs provide their publications and/or publication meta-data to these. However, when it comes to storage and archiving research data, there is currently no clearly identified national e-infrastructure or e-infrastructure collaboration. To add to the complexity of the landscape, it is noteworthy to mention that SLU (and thus TILDA) is not within the auspice of the Swedish Ministry of Education and Research but a university under the Ministry of Enterprise and Innovation.

The national e-infrastructures SNIC and SND are funded through a co-funding scheme between the SRC and a consortium of HEI members and both infrastructures have received funding for the period of 2018-2022 (see Figure 3 for Funding streams). In line with the SRC's model for national infrastructure both SNIC and SND are hosted by a university, which is their legal entity (e.g. UU hosts SNIC and GU hosts SND). The objectives and mandates of SNIC and SND are specified in the respective funding agreement between the SRC and the host university. The host university in turn has to establish consortia agreements with the other universities funding the infrastructures. SNIC and SND have both developed their current strategies through their funding applications and the consortium agreements, and their consortia has agreed on their respective strategies. The infrastructures each have a steering board with a mandate to further develop and implement the respective strategies, in dialogue with the infrastructure's director, the host and the consortium members. The host institution in close dialogue with the consortium members (see Figure 4 for Governance) appoints the members of the steering groups. It can be noted that the main user base of SNIC is found within the HEIs represented in URFI, while the user base of SND is wider and covering a broader range of HEIs (even though the SND consortium only consists of HEIs in URFI).

The Swedish Research Council

The SRC has the responsibility for funding international and national research infrastructures of national interest, including collaborating with other funding and research performing bodies on research infrastructure access and planning. It is the main funding body of public research in Sweden apart from the universities. The SRC funds research infrastructures of national interest through bi-annual calls. As described earlier, the national research infrastructures such as, SND and SNIC are normally co-financed with the universities (Figure 3). Furthermore, the Swedish Government has instructed SRC to also operate and develop the Swedish University computer NETwork, SUNET. Therefore, SRC is also an e-infrastructure provider to universities through SUNET. SUNET is the Swedish National Research and Education Network (NREN) and in this role represents Sweden in NORDUnet and GÉANT, which are collaborations of Nordic and European NRENs.

SUNET is oldest of the present national e-infrastructures with a history dating back to the beginning of the 80's. The national research network has been constantly updated and kept at the forefront of technology, capacity and connectivity. SUNET connected Sweden to Internet and was instrumental in the early and rapid

deployment of Internet in Sweden. In difference to the university-hosted e-infrastructures, SRC has a special commission from the Swedish Government to host and operate SUNET as a provider of networks and associated services for research and education to universities and cultural institutions (museums etc.), including the services towards the international research and education network (Figure 1). SUNET has also the mandate to develop new common services that can be used by the Swedish stakeholders. It should be noted that compared to SNIC and SND the user base of SUNET is much wider and reaches beyond academia. SUNET is provider to, and collaborates with many non-research governmental agencies, including many cultural institutions, the Swedish civil contingencies agency, and the agency for digitalisation (Figure 2). The SRC and the participating institutions provide funding for SUNET. The base funding from SRC to SUNET comes as a directive from the Government with a specified budget. SUNET is governed by a steering group which consists in majority of representatives from the HEIs, and a minority of representatives from the SRC. As the operation of SUNET is only regulated on an overview level in the Swedish Government's instructions[9] to the SRC, it is the duty of the latter to develop and shoulder both the strategic and operational responsibility of this e-infrastructure (Figure 4).

Another related SRC-commission is to promote register-based research, where SRC has introduced an e-infrastructure service in the form of the Register Utiliser Tool (RUT). It should be noted that also for RUT the user base goes beyond research performed at the HEI, including other government authorities, hospitals etc. The activities on RUT are governed within SRC's processes, involving an external reference group. However, the final responsibility for the strategy of both SUNET and RUT lies with the SRC board (Figure 4). In addition to SUNET and RUT, the SRC has a number of other special commissions from the Swedish Government associated to e-infrastructures. One highly relevant is on coordinating the national efforts to instate open access to research data[10] – linked to the commission on open access to publication.

Every four years the SRC produces and updates a roadmap for research infrastructures, including e-infrastructures. This roadmap is used as a national strategy and policy by public and private funders. Sweden has also a number of large research infrastructures (e.g. Max IV, SciLifeLab, Onsala) and is a member of several international research infrastructures (e.g. CERN, ESRF, Elixir). These large-data producing research infrastructures heavily influence the demand on e-infrastructure and the types of services developed. Additionally, the need to manage and analyse sensitive data from registries, databases, medical imaging, sequencing and similar is growing fast, leading to challenges in collaborations across different public sectors with different funding streams. Furthermore, the interests and need for better visualisation of research data is increasing. To date, image databases are often thematic and some universities provide local visualisation centres with limited support and tools.

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[9] https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2009975-med-instruktion-for_sfs-2009-975

[10] https://www.esv.se/statsliggaren/regleringsbrev/?RBID=18539

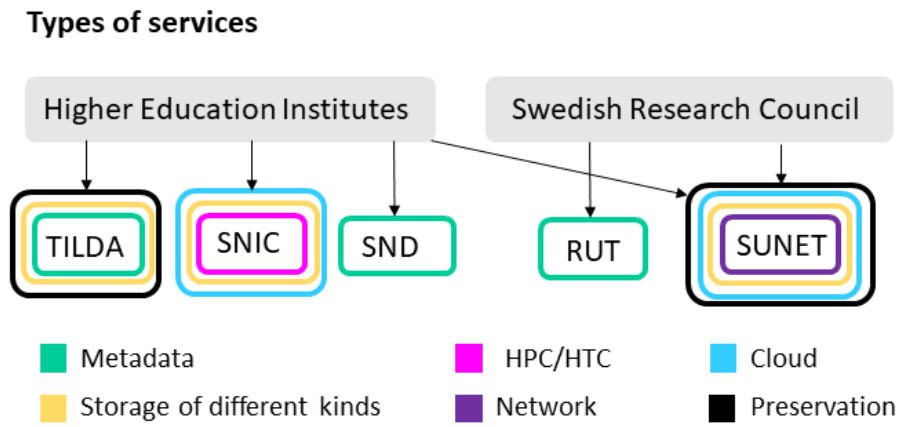


Figure 1. Illustration of the type of services, in a broad sense, that the different actors provide. Arrows indicate governance.

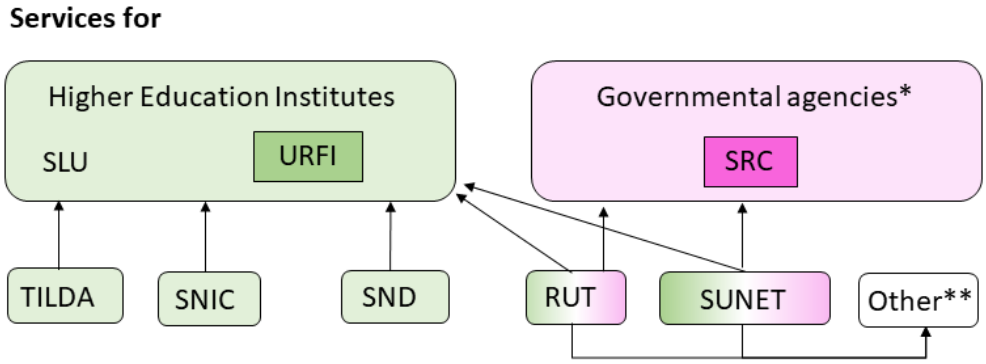


*Figure 2. Illustration of for whom the different e-infrastructures provide services or collaborate on services. *Governmental agencies other than the HEIs. **For example, cultural institutions, Statistics Sweden, quality registers.*

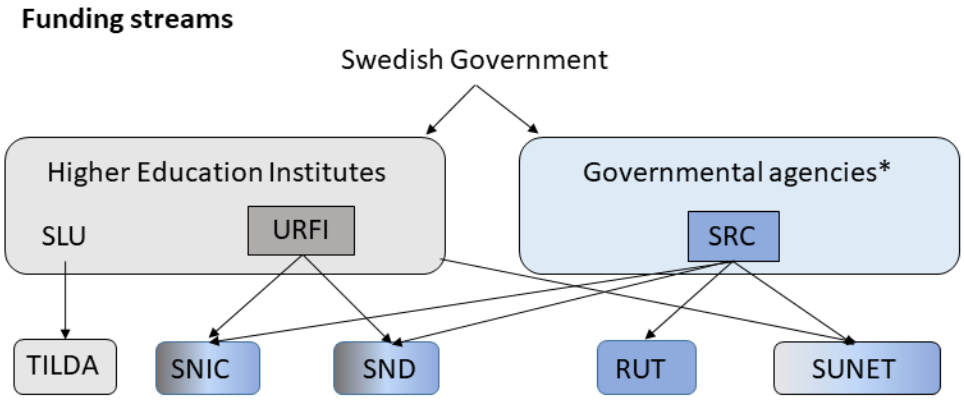


Figure 1. ***Illustration of the funding streams for e-infrastructures. *Governmental agencies other than the HEIs.***

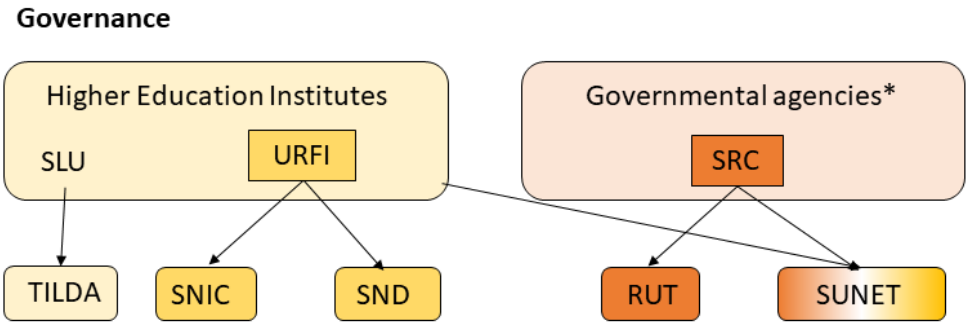


Figure 2. ***Illustration of the governance of e-infrastructures. It is noteworthy to mention that not all HEIs are involved in the governance of SUNET, just a selected few. *Governmental agencies other than the HEIs.***

Gaps, missing functions and services

Though e-infrastructures are included in the national roadmap for research infrastructure Sweden[4] lacks a comprehensive national architecture[11] and policy for e-infrastructure for research. Much of the findings of the panel can be attributed to this fact. Especially, there is a clear lack of a national policy, instructions, and services for research data management and long-term preservation with support and relevant commitments from the HEIs and the SRC. The same is also true, with a few exceptions, on the local level within the HEIs. The effect is that it is often very difficult for the researchers to find a path through the different phases of the research data cycle, e.g. for planning, collecting, processing, analysing, post-processing, and storing of data. A plethora of e-infrastructure actors at different levels (international, national, university, and locally at departments etc.) can be found in the landscape. Due to lack of national policy and instructions, the initiatives act in an uncoordinated way. It seems that there is a common understanding among the HEIs (specifically SUHF and URFI) that there is a need for a national coordination and collaboration on data management planning, and SUHF has recently asked the SRC to be the project leader for the development of tools for data management plans (DMPs). Since the ownership and legal responsibility for research data lies on the HEIs, it is important that they address the challenge and take their responsibility on the national level in this context. Good data management and data stewardship is key for the sharing of research data within national and international collaborations. The element of curation of data is added when moving to long-term storage and preservation. Preservation of digital data will be a major undertaking requiring specific infrastructures, skills and training.

Missing architecture
Model describing the needed and desired e-infrastructure functions to which providers and consumers can be mapped to understand how they have to interoperate legally, organizationally, semantically and technically

The panel has observed that there is currently no *coherent national* solution for data publishing, archiving, and long-term storage, or data preservation for research in Sweden. In addition to SND the most advanced example (known to the panel) is probably the TILDA system at SLU. It will comprise operational data publishing and archiving services when in full operation 2019. Even though the approach of TILDA is generic and could probably be used more widely by others, the present

[11] Model describing the needed and desired e-infrastructure functions to which providers and consumers can be mapped to understand how they have to interoperate legally, organizationally, semantically, and technically, c.f. European Interoperability Framework (https://ec.europa.eu/isa2/sites/isa/files/eif_brochure_final.pdf)

implementation is aimed at specific research domains and has the needs of SLU in focus.

The role of university libraries (and National Library) and their role in supporting research data is rapidly changing. From being service organizations providing access to printed and digital material, there is clear international trend where the university libraries move towards taking a more active role in the knowledge creation at the universities. The libraries have a large potential since they can boost the data management activities and HEIs can exploit their ability and knowledge in organising and providing information, including research data.

In collaboration with SND, several universities are currently planning for local 'data offices', or 'Data Access Units' (DAUs). The focus is to support (meta-) data quality, data deposition, data discovery and knowledge transfer between the universities. It is an initiative that has the potential to enable the universities to better support researchers to provide and fulfil data management plans requested by the funders, e.g. EU. Perhaps at these DAUs, the researchers could also benefit by getting a better overview and means to discover what e-infrastructures services that are available, particularly services to analyse and handle data. This would be particularly useful since the amount of data is growing exponentially and Sweden, as well as the rest of Europe, is moving towards a world where openness and accessibility of research data is expected to be the norm.

To conclude, the current fragmented e-infrastructure landscape in Sweden is not tenable for researchers. It is lacking long-term vision and funding, risk to not be able to serve the rapidly changing and growing needs (especially more advanced research workflows), risk facing difficulties to implement the FAIR-principles, fail to cultivate the know-how, and operate cost-effectively with the existing structures. The individual e-infrastructures are currently to a large degree focused on their own activities and are not considering the capabilities of other e-infrastructures. It is evident that there is no coherent support for the full research project life cycle. There are also no infrastructures or combination of e-infrastructures that can cover all the research needs or all scientific fields.

Ownership, mandate and trust

A basic structural funding for the digital infrastructures for research and education is a clear trend in many developed countries. Having different approaches for funding, governance and organization for the various e-infrastructures (see Figure 2-4) creates an unnecessary barrier for collaboration and even introduce an element of distrust among the e-infrastructures and its stakeholders. This may partially be contributed to by the dual role of the SRC as being both operator and a funder of e-infrastructures. This kind of duality is not uncommon internationally and often work well. Thus, the SRC could mitigate the risks of the dual roles by increasing transparency and better engage with the key stakeholders to re-establish trust and confidence between the actors.

For the universities, the perceived lack of ownership and ability to influence SUNET's strategy appears to be a growing issue. There seems to be challenges with internal communication at the HEIs between the IT-directors, which are usually the contact point for SUNET, and the higher management level. As the questions related to data management and services are increasingly becoming strategic they need to be dealt with at a level where strategic decisions are taken. Strategies for e-infrastructures are coupled with research and education policies at the universities and thus require the university managements' attention – including a strategic approach to services for data management. The observed gap in the internal communication and insufficient coordination within the universities is seemingly also affecting how the university leadership views the SUNET activities. It was noted by the panel that SUNET's steering group is composed of a mix of representatives from the smaller and larger universities, which seems to create a sense of limited ownership of SUNET by the larger research universities and limited insight in the activities and services. As a comparison, this was not observed when it came to for example SNIC, where the largest research universities are partners in the SNIC consortium and involved in the steering committee of the infrastructure.

State of confusion
The lack of ownership and responsibility creates an uncoordinated and reactive response by the actors, which creates confusion and lack of trust

It appears that despite an emerging awareness and willingness to work towards an open research data society the universities have not yet jointly taken up the responsibility to provide their researchers with e-infrastructure solutions that cover the entire research data lifecycle. As a result, e-infrastructures on different levels (local and national) have started to come up with solutions, often emanating from direct contacts with different users and user groups. This results in a landscape that appears quite uncoordinated locally, nationally and internationally. Many initiatives seem to be a reaction to the lack of initiative from the universities and an urgency to

help the research communities to address the emerging data needs and issues. This uncoordinated reactive response is increasingly creating confusion about mandates and contributing to lack of trust between the e-infrastructures, HEI decision-makers and other stakeholders. To provide a few concrete examples based on the panel interviews with e-infrastructures: the SND seems to be focusing a lot on existing data, despite the volumes of new data growing exponentially thus creating mistrust and doubt about SNDs competences in actually being able to provide the services promised to the researchers. Researchers are still uncertain where to turn with their different needs of handling data. Furthermore, there seems to be a limited willingness to collaborate between the SNIC-consortium and SUNET, despite the many obvious benefits that could come if they coordinated their activities better.

To conclude, there is a need to clarify the roles of the HEIs, governing bodies at different levels, and e-infrastructure providers as well as the researchers. Many actors want to have a role in the e-infrastructure landscape but the boundaries and roles in many cases appears to be unclear on many levels (researcher, infrastructures, university management, funding body etc.). The universities seem to see the needs but not know where to seek advice or how to best use the e-infrastructures. It is therefore crucial to increase the knowledge and engagement of the university leadership on this topic and increasing their involvement in the landscape. Only then, can the work and funding of local, national and international e-infrastructures be coordinated and researchers directed to the appropriate service providers.

Cost and funding

It is not always obvious the line between the e-infrastructures and the research infrastructure are drawn. This is for example the case with many large physics facilities, which produce large volumes of data and are now to an increasing extent making it available to other researchers. There is also a growing interest for research e-infrastructures from partners outside academia. Examples are infrastructures like databases, archives and registries, which used to be only for academic research. However, with the new culture of open science and open research data, a much broader community is expected to use the research (e-)infrastructures and their services. Governmental agencies, industry, health sector and sometimes citizens, all use the e-infrastructure services and sometimes contribute with data. One example where the public contributes with observations is Artdatabanken, which is a databank of species where anyone can upload their species data and observations. Artdatabanken is responsible for storage, maintenance and quality of the databank and the usage of data is growing fast. This type of success for e-infrastructures could also be a risk if sustainable business models for their long-term funding is not in place when a growing number of researchers and other users create dependencies on their existence. This is not unique for Sweden, but the Swedish research system, (Government, HEI and funding bodies) need to find sustainable ways for implementing the open data and open science objectives, making the increased opportunities for society at large pay back to research and further the Swedish research excellence.

Sweden in the European landscape

The European Commission has formulated a vision that by 2020 they want ‘all European researchers to be able to deposit, access, and analyse European scientific data through a European Open Science Cloud (EOSC)’. However, in Sweden the work with EOSC does not seem to be coordinated on a national level. There is no single point of contact or stakeholder that is responsible for implementing the vision and being the voice for Sweden in the development of the EOSC. The EOSC is expected to be a federated initiative that will be built on the European member states’ national initiatives and existing activities. Thus, it will be difficult for Sweden to be active if the national actors do not work together in a coordinated fashion. The Government, HEIs, SRC and other funding and research performing organizations need a joint vision that could also be the base of a more formal cooperation with the aim of finding and acting as the voice of Sweden for topics on EOSC. Otherwise, Sweden will have to accept the decisions made by others and hence Sweden is likely to adapt to the changes more slowly. It is unclear to the panel if the universities are happy with the way things are now or if they want Sweden to be more active on the European arena. Other European countries like Finland, France and Netherlands have much more activity in the international arena and can thus influence and shape the European e-infrastructure agenda based on their national policies and strategies. For example, in Finland and Netherlands there are centralised e-infrastructure organizations that are very prominent in executing the position of the respective country in the EOSC debate. If Sweden wants to have an impact on the EOSC and other future European initiatives, it is urgent to get coordinated and act for building awareness with a common purpose.

Concluding observations and recommendations

As conclusion a number of recommendations are presented, which we believe would improve the e-infrastructure landscape in Sweden and promote a healthy science landscape in a digital society where digital experiments and simulations, encompassing the FAIR-principles, is becoming standard. The recommendations have been clustered based on topic and timing but the numbering does not follow any special priority by the panel with one exception. The panel would like to emphasize the high priority of recommendation 3, since many of the other recommendations depend on the formulation of a national strategy for e-infrastructures for research. The strategy should have clear links to the national activities with Open Science, since this new paradigm is a strong driver on how e-infrastructures are organized, funded and developed to deal with future challenges.

Observations	**Recommendations**
Medium-term (within 1-5 years)	
1. Lack of national governance framework and strategic lead of e-infrastructure to support data-sharing within society at large 2. The existing e-infrastructure for research and higher education are used to a limited degree by other sectors today 3. Lack of national strategy for e-infrastructures within higher education and research	**1. The Swedish Government should organize a national discussion with the aim of establishing a common awareness of the importance of e-infrastructure that enable data-sharing within and across sectors** **2. The Swedish Government should encourage all sectors (including health and industry) to benefit from the existing e-infrastructures** **3. The Swedish Government should task the SRC to establish a national committee** **a) where funding bodies and HEIs develop a common strategy for e-infrastructures for research** **b) The national committee should engage in developing future models for funding streams for e-infrastructures to implement and develop services based on stakeholder needs.**

Observations	Recommendations
4. The data landscape is fragmented which is confusing researchers. There is a lack of communication and collaboration between competent providers. There is uncertainty in the mandate of different actors (self and others)	**4. The national committee should** **a) ensure the establishment of an overarching architecture[10] for e-infrastructure supporting the e-infrastructure strategy. As a result, of the architecture, the mandates of the current e-infrastructure providers (e.g. SUNET, SNIC, SND) should be re-established and clarified. The committee should ensure continued governance (development) of the e-infrastructure strategy and architecture** **b) ensure the establishment of a national e-infrastructure service catalog**
5. Lack of trust and communications between the different national e-infrastructures, resulting in competition nationally and suboptimal engagement on international level	**5. The national committee should encourage operational engagement and involvement. The e-infrastructures should be empowered to engage in the international arena in line with national policies and targets**
	Short-term (within 1 year)
6. Lack of documented national policy on open research data and open science	**6. The SRC has this mandate[9] and should develop this by engaging relevant actors and raise awareness in the sector**
7. No coherence in e-infrastructures' support of open science and open data	**7. The national policy needs to include e-infrastructures and explain the task of coordination of open data services**
8. Other actors are confused about the SRC's dual role as a	**8. The SRC needs to** **a) be more transparent with the two roles**

Observations	Recommendations
funder and provider of e-infrastructure	**b) be a committed owner of the e-infrastructures which they have been tasked to operate like SUNET and RUT**
9. The impact of SUNETs activities has become more important and embedded in the strategic thinking of research and there is not enough commitment from the HEIs on the strategic development of SUNET	**9. The HEIs should agree together and with the SRC on how to build a shared ownership of SUNET**
10. Many e-infrastructures are working with data and data management plans but there is no coherent national framework for this	**10. A national plan for open science should cover a coherent national framework for data management plans**
11. The researchers are not obliged to provide data management plans to funders	**11. The SRC should require data management plans to ensure a healthy science landscape** **The HEIs should ensure the means (e-infrastructure, competence, services etc.) are available for the researchers to fulfil this requirement. This includes linking data to publications and long-term preservation of data**

Tabell 1. Panel recommendations

Final remarks

Sweden has the cornerstones to have a well-developed e-infrastructure landscape for research. Some of the actors are perceived very mature, have clear mandates, whereas others are undergoing a structural change, and need to find their identity. The strength in the system lies in the fact that all actors are keen on finding a solution and collaborate to enable the best services for the researchers, meet the researcher needs and enable excellence science.

During the work, we have observed that a re-occurring theme is the fragmentation of e-infrastructures and differences in ownership and funding mechanisms and the problems this causes in terms of unclear, sometimes seemingly overlapping mandates, gaps of services and confusion among e-infrastructures, universities, and within the SRC. This is of course also a concern for researchers whose research rely on access to e-infrastructures where the risk is that Swedish research will be left behind. The fragmentation has been highlighted in previous studies and reviews from the SRC[1, 3] and the e-infrastructures have been encouraged to coordinate and collaborate more. Nevertheless, the situation has not improved (rather the opposite) over the past 5-10 years and we therefore recommend that Sweden now strongly considers a more unified and coherent strategy and organization of e-infrastructures.

A first step in this process is to work towards organizational interoperability among the existing e-infrastructures, including tightly connected and compatible governance structures and clear ownerships of the strategy processes. In addition, the owners of the national e-infrastructures urgently need to agree on the national e-infrastructure architecture[10] and the individual infrastructures tasks within this landscape. A second step is to evaluate if the current diversity of national e-infrastructures could be reduced in terms of the number of e-infrastructure organizations. There are several models of how a unified and coherent national e-infrastructure may be organized, one being the Dutch model – the SURF cooperative – with universities, university of applied sciences, and university hospitals as members. Another architecture being the Finnish model with a centralized CSC - IT Center for Science, a not-for-profit limited company owned by the Government (70%) and the HEIs (30%). Other forms of organizational models are currently being introduced in Norway and Denmark, where the processes of unifying or more tightly coordinating the national e-infrastructures seems to have proceeded. **Based on the observation that the current fragmentation is becoming increasingly challenging and is probably not cost efficient, the panel recommends that now is the time to consider an encompassing national e-infrastructure coordination and even organizational mergers of e-infrastructures.** However, which type of organization Sweden should aim for needs to be further investigated in terms of legal and cultural (i.e. what is agreed on by the HEIs and the SRC) aspects.

The proposed path towards unification is driven by several factors. The most obvious is that a more coherent organization of e-infrastructures will be better suited to serve excellent science in a cost-efficient way. Furthermore, the panel expects that, in a 5–10 year perspective the user base of e-infrastructures is going to become

even more diverse and include a growing number of researchers with less experience in digital research and also researchers that are based outside of universities, e.g. in hospitals and industry. Such users cannot be expected to navigate within a plethora of e-infrastructures and this should be another strong driver for rethinking how e-infrastructures are organized. There is a need of services to support advanced work-flows that include both national and international digital public and commercial resources.

List of abbreviations

DAU	Data Access Unit
DMP	Data Management Plan
E-IRG	e-Infrastructure Reflection Group
EOSC	European Open Science Cloud
FAIR	Findable, Accessible, Interoperable, Reproducible (FAIR-principle)
GU	Göteborg university
HEI	Higher Education Institutions
HPC	High Performance Computing
HTC	High Throughput Computing
ICT	Information and Communications Technology
RFI	Swedish Research Council's Council for Research Infrastructures
RUT	Registry Utilizer Tool
SLU	Swedish University of Agricultural Sciences
SND	Swedish National Data service
SNIC	Swedish National Infrastructure for Computing
SRC	Swedish Research Council
SUHF	Association of Swedish Higher Education Institutions
SUNET	Swedish University computer NETwork
URFI	University reference group for research infrastructures
UU	Uppsala university

Appendix – Declarations of independence

The eight following pages contain declarations of independence from the following:

Anna Wetterbom
Lars Lindsköld
Erik Fledderus
Per Öster
Sverker Holmgren
Riitta Maijala

Declaration of confidentiality, interests and conflicts of interest

The undersigned..... Anna Wetterborn .....,
..... CEO The Young Academy of Sweden .....

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity

- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.

- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

I was employed at the Swedish Research Council (SRC) 2012-~~2016~~ 2017 at the research infrastructure unit. In this role I represented Sweden and the SRC in the governing bodies of e-IRG and ELIXIR. I also co-authored the part on research data in the SRC report "Proposal for national guidelines on open access to scientific information". During 2016 I had a 50% secondment as a non-political expert (on research infrastructures, digitilization and open access/open science) at the Ministry of Higher Education and Research.

(b) Current activities:

CEO of the Young Academy of Sweden (full time position). Chair of the joint steering group of the national biodiversity infrastructures Swedish Lifewatch and Biodiversity Atlas Sweden. Senior advisor to the think tank *Global utmaning*.

(c) Current Financial Interests

No Interest Declared

(d) Any other relevant interests.

No Interest Declared

(e) Family Member Interest

No Interest Declared

I confirm the information declared on this form is accurate to the best of my knowledge and I consent to my information being stored and published by the Swedish Research Council.

.....

Uppsala, 2018-10-31

Declaration of confidentiality, interests and conflicts of interest

The undersigned Lars Lindsköld, Portfoliomanager,SweLife /Sweper, Regional developer, Västra Götalands regionen, adjunct lector ITIT, Gothenburg University , Sweden

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity
- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.
- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

Regional developer officer VGR since 2006
adjunct lector ITIT, Gothenburg University since 2016
Portfoliomanager,SweLife /Sweper since 2017-12

(b) Current activities:

See above.

(c) Current Financial Interests

No Interest Declared

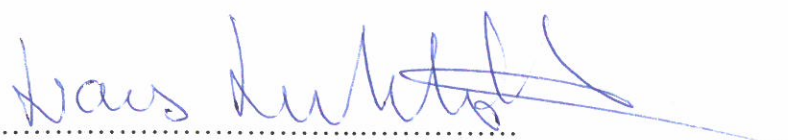
(d) Any other relevant interests.

No Interest Declared

(e) Family Member Interest

No Interest Declared

I confirm the information declared on this form is accurate to the best of my knowledge and I consent to my information being stored and published by the Swedish Research Council.



Lars Lindsköld, Göteborg 2018-10-31

Declaration of confidentiality, interests and conflicts of interest

The undersigned, Erik Fledderus, managing director and chair of the executive board of SURF.

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity
- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.
- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

Apart from current activities that started 5 or more years ago, the following activities ended in the last 5 years:

- Chair of DG Connect Advisory Forum (CAF), advising on ICT in the H2020 work program for the years 2016/2017, and 2018-2020.
- Member of SNIC panel, review of future vision on Swedish supercomputing infrastructure
- Member review panel, Finnish e-infra roadmap 2017
- Member review panel, Finnish research-infra roadmap 2018
- Member of the (Dutch) ICT Advice committee
- Chair of the board of the Joint Institute for Innovation Policy (JIIP), a joint-venture of TNO, VTT, Joanneum Research and Tecnalia.
- Member of the board of the Dutch Creative Industries, CLICKNL
- Member of technical committees of the Council for the Environment and Infrastructure (Beyond Mainports, Connecting the Dots – on scouting technological innovations)
- Member of the board of the Knowledge platform Electromagnetic Fields and Health

(b) Current activities:

- Since May 2015: managing director and chair of the executive board of SURF, The Collaborative ICT Organisation for The Netherlands;
- Since June 2015: national delegate in the e-Infrastructure Reflection Group (e-IRG)
- Since October 2016: member of the national ICT-top team, on promotion of ICT-innovation and strengthening the relation between public research institutes and companies in the area of digital transformation
- Since December 2017: board member of the (Dutch) National Platform Open Science
- Since March 2003: part-time professor at the Technical University Eindhoven in the field of wireless communication

(c) Current Financial Interests

No Interest Declared

(d) Any other relevant interests.

No Interest Declared

(e) Family Member Interest

No Interest Declared

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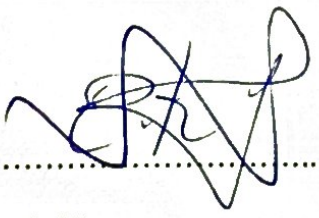


.....

Erik Fledderus,
Oct 31st, 2018

Declaration of confidentiality, interests and conflicts of interest

The undersigned.....Per Öster..... ,

.....Director Research Infrastructures and Policy, at CSC – IT Center for Science.....

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity

- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.

- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

▪ 2015 1 March – 2018 28 February, Chair of EU H2020 Project "EUDAT 2020" Executive Board

▪ 2013 July 1 – 2015 June 30, Member of the board, Stichting European Grid Initiative (EGI.eu), Amsterdam, Netherlands.

(b) Current activities:

Director Research Infrastructures & Policy at CSC – IT Center for Science Ltd. Finland

Chair of the Board of Directors of EUDAT Ltd.

Project Director EU Project EOSC-hub

Member of Swedish Research Council Advisory for research infrastructures

Deputy board member NORDUnet

(c) Current Financial Interests

No interest declared

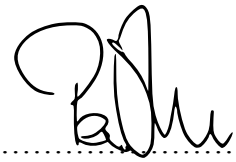
(d) Any other relevant interests.

No Interest Declared

(e) Family Member Interest

No Interest Declared

I confirm the information declared on this form is accurate to the best of my knowledge and I consent to my information being stored and published by the Swedish Research Council.



……..……

Per Öster, 1 November 2018

Declaration of confidentiality, interests and conflicts of interest

As the undersigned Sverker Holmgren, Professor,

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity

- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.

- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

For transparency, I below state past appointments and assignments during the last five years that are related to the task as a member of the Swedish Research Council´s (SRC) and the University Reference Group for Research Infrastructures (URFI) panel on a national e-infrastructure roadmap:

- Until the end of 2017, I was appointed by the University of Gothenburg as a member of the Steering Board of the Swedish National Data Service (SND). During the last two years, SND produced and submitted an application to the SRC which resulted in funding decisions by the SRC and the SND consortium for the period 2018-2022.

- During 2016, I was appointed by Uppsala University (UU) and URFI as the chair of a national expert group providing a proposal of SNIC 2.0 (SNIC during 2018-2022) in response to a request from the SRC. This description was the basis for funding decisions for SNIC 2.0 by the SRC and the HEIs in URFI.

(b) Current activities:

- I am currently a member of the UU Council for Research Infrastructures. This body is an advisory body to the Vice-Chancellor of UU.

- I have been a member of the Board of Trustees for the Swedish Academic Identity Federation (SWAMID) since 2011.
- I am the coordinator of NordForsk´s Strategic Initiative on Research Infrastructure, including coordination of a Nordic group of leaders of research infrastructure funding agencies, since January 2017.
- I am appointed by the Swedish Ministry of Education as the Swedish representative in the European e-Infrastructure Reflection Group (e-IRG) since 2008. I am also appointed by e-IRG as the e-IRG representative in the European Strategy Forum for Research Infrastructures (ESFRI) Implementation Group.
- I am appointed by the European Commission (DG CNCT) as a Member of an External Board overseeing the implementation of e-infrastructure for the EOSC. This Board is providing recommendations on how the current H2020 e-infrastructure projects EOSChub and OpenAIRE Advance should prepare for the EOSC.

(c) Current Financial Interests

No Interest Declared

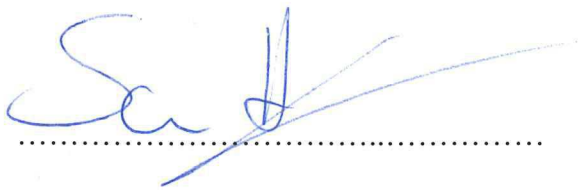
(d) Any other relevant interests.

No Interest Declared

(e) Family Member Interest

No Interest Declared

I confirm the information declared on this form is accurate to the best of my knowledge and I consent to my information being stored and published by the Swedish Research Council.



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Sverker Holmgren
2018-11-01

Declaration of confidentiality, interests and conflicts of interest

The undersigned Riitta Maijala, Vice President, Academy of Finland,

I hereby declare,

- that I have performed my duties in the general interest of the Swedish and international research community, to the best of my capacity
- to ensure the confidentiality of all opinions that were expressed by other panel members and participants during discussions in meetings or provided in written form for this work.
- that to the best of my knowledge, the only direct or indirect interests and bias that I have in the report and its recommendations are those listed below:

(a) Past activities:

- 2015-2016 Director, Thematic research funding, Academy of Finland, Helsinki
- 2013-2015 Director, Science Policy Division, Ministry of Education and Culture, Department of Higher Education and Science, Helsinki
- 2013-2016 Vice Chair of the Expert Group for Research Infrastructure, Academy of Finland
- 2016-2018 Member of the NordForsk Board
- 2014-2016 Chair of the Steering Group of Open Science and Research, Ministry of Education and Culture
- 2013-2015 Member of the European Research Area Committee
- 2013-2015 Member of the ICT-2015 group, Ministry of Education and Culture

Current activities:

- 2016- Vice President, research, Academy of Finland, Helsinki
- 2016- Finnish Delegate of the European Strategy Forum on Research Infrastructures (ESFRI)
- 2017- Chair of the Nordic Cooperation Committee for Research Infrastructure, NordForsk
- 2016- Chair of the Finnish Research Infrastructure Committee, Academy of Finland
- 2018- Vice Chair of the Nord Forsk Board
- 2018 - Member of the Research, development and innovation subgroup of the higher education and research Vision 2030 implementation plan. Ministry of Education and Culture, Finland.

- 2018- Member of the National Strategy Group for Open Science, The Federation of Finnish Learned Societies
- 2017- Debuty member of the Data management and computation steering group. Ministry of Education and Culture, Finland.
- 2016- Member of the Science Europe

(b) **Current Financial Interests**

No Interest Declared

(c) **Any other relevant interests**

No Interest Declared

(d) **Family Member Interest**

No Interest Declared

I confirm the information declared on this form is accurate to the best of my knowledge and I consent to my information being stored and published by the Swedish Research Council.

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Riitta Maijala, 31.10.2018

Many reports by the Swedish Research Council (SRC) have identified a growing need for e-infrastructures for research. However, in Sweden, the current e-infrastructure landscape is relatively fragmented and many actors provide different kind of services at different levels. At the same time, the global Open Science policy in research pushes the need for national alignment with international policies and good national coordination between infrastructures and e-infrastructures for research. The Swedish Research Council and the University reference group for research infrastructures (URFI) identified a need for a review to get an independent advice from an international expert panel on how to deal with the growing demands for e-infrastructures for research. As a collaborative effort, SRC and URFI initiated this review in October 2017.

During the work, the expert panel observed that a re-occurring theme is the fragmentation of e-infrastructures and differences in ownership and funding mechanisms and the problems this causes. The panel has proposed eleven specific recommendations on how to continue the work for developing a coherent national strategy and roadmap for e-infrastructures for research.

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