Result of Needs Inventory

Appendix to the Swedish Research Council's Guide to Infrastructure 2018

Swedish Research Council

2018

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Foreword

The ability of researchers to conduct advanced research often requires access to resources that are built up systematically over a longer period of time, and that normally exceed the needs of individual teams of researchers. Examples of these are major research facilities, laboratory environments, experimental workshops, complex digital research systems and databases. This type of research resources provide the prerequisites for long-term research within entire research fields, which is why we describe them as research infrastructures.

The Swedish Research Council's definition of research infrastructure of national interest is: *A research infrastructure of national interest is intended to provide resources that enable research for several research teams and different projects within one or several research fields.*

The Swedish Research Council's support to research infrastructure shall provide long-term prerequisites for conducting research of the highest international quality, safeguard national accessibility to research infrastructure, enable renewal within the Swedish infrastructure landscape and support a long-term approach to funding and participation by higher education institutions (HEIs).

In 2017, the Swedish Research Council conducted for the second time an inventory of the new needs for infrastructure identified by research teams or the managements of the country's HEIs. The areas identified in this process that have been assessed as having the highest priority have been included in this Guide Appendix.

As the greater part of the Swedish Research Council's budget for research infrastructure is tied up in long-term engagements, it has become increasingly important to prioritise among existing and new undertakings, to ensure the resources are used in the best possible way. The role of the Swedish Research Council is to provide prerequisites for the very best research by contributing to the best infrastructure.

The Council for Research Infrastructures (RFI) wishes to thank several persons and groupings who have provided inputs to the work on this Guide Appendix. In addition to all who have made proposals for new infrastructure needs in conjunction with the inventory, and RFI's advisory groups, which have assessed the proposals submitted and assisted in the production of texts, consultations with the Swedish Research Council's scientific councils, the Committee for Educational Sciences and the Universities' Reference Group for Research Infrastructure (URFI) have been very valuable.

Björn Halleröd
Secretary General, Research Infrastructures

Jan-Eric Sundgren
Chair, Council for Research Infrastructures

Summary

Just under 100 proposals from higher education institutions, public authorities with research responsibilities, funding bodies and research groups were received by the Swedish Research Council during the inventory of needs for new or upgraded/improved research infrastructure conducted in 2017–2018.

The advisory panels under the Swedish Research Council's Council for Research Infrastructure (RFI) have assessed all proposals received on the basis of criteria such as scientific relevance, national interest and strategic considerations. During the assessment, statements from the Research Council's scientific councils and committees and the universities' reference group for infrastructure were also considered. This assessment, including a proposal for categorisation, was further processed and then adopted by the RFI.

The thematic areas that were placed into the categories A1 (high scientific and strategic value, ready for implementation during 2020), A2 (high scientific and strategic value, but at the moment not prioritised for funding by the Swedish Research Council) and A3 (high scientific and strategic value, but not ready for implementation) in the assessment are described in more detail in this Appendix to the Swedish Research Council's Guide to Infrastructures. This includes 14 areas within category A1, 3 within category A2 and 16 within category A3. In addition to this, infrastructures for which the grant period ends in 2019 or 2020, and thus eligible to apply for infrastructure grants in the 2019 call for proposals, are also listed. In some cases, this means that they need to be part of one of the thematic areas described in A1.

In the Guide Appendix, there is also a description of how the assessment of the proposals of needs was conducted, the upcoming call in 2019 and the strategic roadmap, the Swedish Research Council's Guide to Infrastructures, which is also published in 2018.

Sammanfattning

Vid den inventering av behov av ny eller uppgraderad/utvecklad forskningsinfrastruktur som Vetenskapsrådet genomförde under 2017–2018 inkom knappt 100 förslag från lärosäten, myndigheter med forskningsansvar, finansiärer och forskargrupperingar.

Vetenskapsrådets Råd för forskningens infrastrukturer, RFI:s, rådgivande grupper har bedömt alla inkomna förslag efter kriterier såsom vetenskaplig relevans, nationellt intresse och strategiska överväganden. I bedömningen har även yttranden från Vetenskapsrådets ämnesråd och kommittéer samt lärosätenas referensgrupp för infrastruktur vägts in. Bedömningen, med förslag på kategorisering, bearbetades och fastställdes sedan av RFI.

De tematiska områden som i bedömningen placerades i kategorierna A1 (högt vetenskapligt och strategiskt värde, redo för implementering fr.o.m. 2020), A2 (högt vetenskapligt och strategiskt värde, finansiering i nuläget inte prioriterad av Vetenskapsrådet) och A3 (högt vetenskapligt och strategiskt värde, men inte redo för implementering) beskrivs närmare i denna bilaga till Vetenskapsrådets guide till infrastrukturen. Det rör sig om 14 områden i kategorin A1, 3 i kategorin A2 och 16 i kategorin A3. Utöver dessa listas även infrastrukturer vars bidragsperiod tar slut under 2019 eller 2020 och som därmed är behöriga att ansöka om infrastrukturbidrag i utlysningen 2019. I vissa fall behöver de ingå i ett av de tematiska områdena som beskrivs i A1 för att få ansöka.

I bilagan beskrivs även hur bedömningen av behovsanmälningarna gått till samt den fortsatta hanteringen med utlysning 2019 och den strategiska vägvisaren för infrastruktur, Vetenskapsrådets guide till infrastrukturen, som också publiceras 2018.

Background

About the needs inventory

A new model for prioritising and funding research infrastructure was adopted by the Board of the Swedish Research Council in 2014. The model, which has since then been introduced in stages and will be fully implemented in 2019, follows a two-year cycle starting with a needs inventory and ending with a targeted call. Starting in 2015, the needs inventory is carried out every two years. Researchers, higher education institutions (HEIs) and public authorities with research mandates can notify needs for infrastructure of national interest to the Swedish Research Council. Via a review process, areas are identified where research is assessed as having a great need for new or expanded infrastructure. The result is presented in this Appendix to the Swedish Research Council's Guide to Infrastructure, where the needs for future research infrastructure are summarised and described. RFI and RFI's advisory groups play central roles in the assessment, but consultation with the Swedish Research Council's scientific councils, the Committee for Educational Sciences and the HEI's reference group for infrastructure (URFI[1]) is also of great importance.

The results of the needs inventory then forms the basis of a targeted call. However, all areas identified in the Guide Appendix are not covered by the call. RFI decides on the areas to be included in the call on the basis of strategic consideration of the scientific benefit to Swedish research, an assessment of how well-developed and realistic the planning of the identified infrastructure is, and a budgetary assessment. As infrastructure of national interest requires national mobilisation and coordination, a coordinated application is normally expected for each area covered by the call. This means that each application is assessed in particular on the basis of its ability to meet an already identified need for infrastructure.

In conjunction with funds being made available in the call for the areas identified in the needs inventory, existing infrastructures financed via RFI are also offered the opportunity to apply for renewed funding. For these, a report on the operations carried out is also required, so the application thereby also functions as an evaluation. By using the same review process to evaluate older infrastructures that need continued funding and infrastructures within new or associated areas, prerequisites are created for a process that balances long-term stability against necessary renewal.

A strategic roadmap, the Swedish Research Council's Guide to Infrastructure, is published every four years. The purpose is to indicate a desired direction for Sweden's work with research infrastructure, and to identify issues that should be addressed during the upcoming period.

1 Representatives at management level from the ten largest Swedish HEIs and a representative from the Association of Swedish Higher Education Institutions (SUHF)

Assessment of the needs proposals 2017–2018

The needs proposals received by the Swedish Research Council during autumn 2017 were assessed based on their scientific and strategic value, with the support of RFI's three advisory groups. Statements from the Research Council's scientific councils and committees and the universities' reference group for infrastructure were also considered in the assessment.

In the assessment process, the majority of the needs proposals received were grouped into thematic areas, which were then divided up into seven categories, from A1 to X:

A1 = Relevant for consideration as infrastructure of national interest, ready for call
A2 = Relevant for consideration as infrastructure of national interest, but funding currently not prioritised by the Swedish Research Council
A3 = Relevant for consideration as infrastructure of national interest, but not ready for call
B = Not relevant for consideration as infrastructure of national interest, due to ...
C = The need can be covered by existing national or international infrastructure
D = Should be handled by another organisation or by another method, namely ...
X = Could not be assessed due to lack of information or unclear description

The thematic areas in the categories A1, A2 and A3 have been included in this Guide Appendix. Areas assessed as being of high scientific and strategic value, and where the plans for a national infrastructure are sufficiently clear for them to start in 2020 (after the call in 2019) have been classed as A1, while those that are of high scientific and strategic value but require more time before they can be considered for implementation are classed as A3. The fact that an area has been categorised as A1 is therefore a prerequisite, but not a guarantee, for being included in the next call. Infrastructures categorised as A2 were assessed as being scientifically and strategically important and ready for implementation, but for various reasons the Swedish Research Council has chosen not to include them in the call.

Areas in the categories B–X are not included in the Guide Appendix. The decision on the contents of this Guide Appendix was made by RFI in September 2018. The text in the Guide Appendix has thereafter been edited as necessary before publication.

Call 2019

The decision on the areas from category A1 to be included in the 2019 call was made by RFI during autumn 2018. The call will not be limited to those responsible for a submitted a needs notification, however. Other actors who wish to take part in the building up or operation of an infrastructure within the areas included in the call and that fulfil the criteria of the call may be included in an application.

In addition to the new areas, existing infrastructures for which the grant period is ending will be able to submit applications for renewal of their grants. A list of these can be found under the heading "Research infrastructure funded by the Swedish Research Council". More information about these is available on vr.se.

In addition to the infrastructures listed in the above-mentioned section, grants may also be applied for to fund increased Swedish engagement in international

infrastructures in which Sweden is already participating. This should be in response to clear processes, such as calls for contributions in kind or similar within the infrastructure in question, in which Swedish researchers intend to participate.

The call will be published in early 2019. Further information will be available on the Swedish Research Council's website, vr.se, during autumn 2018.

The continuing process

The next needs inventory will start during autumn 2019. Information on the criteria and timings that apply will be notified during the year. The result of the inventory will be presented in 2020.

The strategic roadmap, the Swedish Research Council's Guide to Infrastructure, was published in 2018 and indicates a 5–10-year horizon for a desired development to safeguard Swedish researchers' access to first-class research infrastructure. The Guide is produced in parallel with the Swedish Research Council's work to produce documentation ahead of the Government's Research Bill 2020, and also includes recommendations for initiatives and system changes.

Timeline

2017
- Call for "Infrastructure of national interest"
- Needs inventory

2018
- The Swedish Research Council's Guide to Infrastructure 2018, including a Guide Appendix based on the needs inventory, is published

2019
- Call for "Infrastructure of national interest"
- Needs inventory

2020
- The Swedish Research Council's Guide to Infrastructure, based on the needs inventory 2019, is published

2021
- Call for "Infrastructure of national interest"
- Needs inventory

Needs for research infrastructure per area (A1, A2 and A3)

This section describes, in alphabetical order, a number of areas with research infrastructure needs that are considered of national interest. Areas where the infrastructure needs are considered of national interest and are ready to be implemented in the near future are described under A1. Those described under A3 are considered as potentially equal in importance to A1, but require more time for planning before they can be implemented. Proposals that are considered important and ready to be implemented, but where the Swedish Research Council for strategic reasons does not intend to include them in the call, are classed as A2.

The idea is that the descriptions herein should provide inspiration and support to organisations and research teams that wish to develop national infrastructure, and also to funding bodies that are interested in contributing to such infrastructure. The aim of the Swedish Research Council is to describe challenges and expected results for each area, but not to propose any concrete solutions. It is up to the parties that intend to build up and operate the infrastructure to describe how the specific infrastructure needs should best be met. Other infrastructure than that described in the Guide Appendix, with or without grants from the Swedish Research Council, may also be included in the proposed infrastructures. It is, however, of crucial importance that there is a national perspective, that the infrastructure is openly accessible according to scientific prioritisation, and that the relationship to infrastructure within or in close proximity to the area is described.

A1
Relevant for consideration as infrastructure of national interest, ready for call 2019

Contextual databases for social sciences

Challenge: Today's world is facing multiple major known challenges: ageing populations, increasing social inequality, climate changes, conflicts, political populism, changed migration patterns, etc. To address these challenges, knowledge needs to increase of both their causes and their consequences. Furthermore, we need increased understanding of how challenges are related to each other. Within social sciences research, analysis is done of factors such as the consequences of various social, political, economic and environmental structures, and prerequisites for

individuals' living conditions, values and behaviours. These prerequisites cover everything from global to local factors, and involve both changeable structures and factors that are difficult to influence. To analyse and understand the actions of individuals, we therefore need not just longitudinal individual-based data, but also data at aggregated, contextual level.

Description: Sweden has a large number of high-quality contextual databases. Swedish research in several of the areas where contextual databases are used is of high international standard. Sweden's position within the research field can be further reinforced through the formation of a national research infrastructure for contextual data. Through increased coordination of existing databases, and in particular future data collection, opportunities are created for pioneering research within fields such as democracy development and social policy.

Swedish researchers have managed to build up several databases for context-based data. These cover a broad spectrum of contextual information; everything from armed conflict and corruption to the quality of government governance and social security. However, existing databases vary not only in terms of content, but also in terms of time period and number/type of countries covered by data. Some have global coverage, while others focus on high-income countries. Research places very high demands on systematic information relating to contextual factors at various levels. New theories require information on a number of different factors. There is great potential for coordinating and linking various existing databases, in order to create synergy effects that can facilitate ground-breaking research. This applies in particular to global challenges, such as the UN's Sustainable Development Goals for 2030, but also regional analyses, where the population composition, political measures and other contextual factors can vary.

Expected results: Coordinated organisation of contextual databases based on long time-series would enable and facilitate analysis of causes of institutional and societal changes and their consequences for individuals at various stages of life. The focus would move from descriptive analyses to causal analyses. Coordination of this type of databases would promote comparative (country-comparing) research and in this way be of great importance also for the study of sustainable development. In summary, a national infrastructure for context databases is of importance, for both Swedish and international social sciences research.

Infrastructure for brain imaging

Challenge: The brain is our most complex organ, and affects the entire body and our behaviour. As we grow older, the incidence of diseases such as stroke and dementia increases, which does not just impact on the individual but on society as a whole. Research within the area concerns both health and disease, and how the brain processes information. Brain imaging can be carried out using many different techniques, which are partially complementary. Coordination of infrastructure for brain imaging is necessary in order to enable access for researchers throughout the country. Magnetoencephalography is considered a central need, but other forms of brain imaging can be included, on condition that added value can be gained from the coordination.

Description: NatMEG is the first and only research laboratory in Sweden for overall measurements of neuronal brain activity using magnetoencephalography (MEG). Magnetoencephalography is a method for measuring bio-magnetoelectric signals to reflect the work of the brain in humans, and provides opportunities to measure brain function at millisecond level. The method can localise the brain's activity with great precision and allows study of phenomena that are associated with thinking, experiencing and feeling. The technique is relatively uncommon, with around 170 similar instruments in the world, of which fewer than 50 are in western Europe.

Expected results: An upgrade of the national infrastructure NatMEG within MEG instrumentation, MEG and EEG analysis and user services in particular, and a possible integration of other existing platforms, would crucially strengthen the competitiveness of Swedish researchers within cognitive neuroscience, clinical neuroscience, clinical implementation, instrumentation and calculation modelling, and is expected to attract additional users within life sciences. The planned improvements would strengthen Sweden's position within the brain imaging area.

Infrastructure for chemical biology

Challenge: Finding out how small molecules with biological activity function and how they can be used is a central part of life science and biomedical research, and also has great potential within plant biology and environmental sciences. Within pharmacology, for example, there is currently only access to well-characterised pharmacological substances for a limited number of all proteins. To enable effective research into new parts of the proteome, development of new tools and methods is needed. It is often too great a challenge for individual research teams to develop and maintain the necessary infrastructure for discovering new small molecules with biological activity, and to characterise and validate these.

Description: Chemical biology includes research methods within chemistry that are used to understand, control and change fundamental biological processes. Screening, characterising and optimising small molecules with biological activity are central features of chemical biology. Infrastructure within chemical biology can also include access to molecule libraries, resources within synthetic chemistry, screening of entire organisms and support for computational chemistry.

Expected results: Within life sciences, research at an infrastructure for chemical biology is expected to lead to increased characterisation of the human proteome, better understanding of biological processes in healthy and ill persons, and identification and development of new medicines. Within environmental sciences and plant biology, an infrastructure is expected to lead to development of new biodegradable biocides and new biofuels, for example.

Infrastructure for experimental research using large animals

Challenge: Translational research means that research questions identified within healthcare are addressed experimentally in a laboratory to provide an answer that can then be implemented in healthcare in the form of improved diagnostics or therapies. Within this type of research, there are needs for various animal models that

resemble humans. The use of cows and pigs, for example, for this purpose therefore fulfils an important function. There is also a need for deeper knowledge about diseases in animals that may have consequences for animal husbandry and food production as well as for human health. Better access to models for research into large animals is requested both at HEIs and in industry.

To develop the use of large animal models, there is a need for an integrated approach and collaboration between experts in both veterinary and human medicine. A platform where these disciplines can collaborate would enable innovative research, for example within antibiotics resistance, xenotransplantations, ageing, orthopaedics, and cardiology.

Description: In addition to coordinating activities at the various facilities of the infrastructure, education in animal health, animal ethics and relevant surgery for veterinary medicine interventions should be part of the infrastructure. Here, expertise within veterinary medicine and livestock science, which is today available at the Swedish University of Agricultural Sciences, will play an important role. Creating opportunities to carry out long-term studies will also be a task for the platform.

Expected results: Access to infrastructure for large animal models is expected to provide increased opportunities for translational research in Sweden, better knowledge of animal diseases and animal health and, in the longer term, improved methods within healthcare.

Infrastructure for metabolomics

Challenge: Disruption of an organism's metabolism can cause various problems and diseases. Using mass spectrometry, small organic molecules (metabolites) in biological samples can be analysed and contribute to new knowledge about fundamental biological processes. An alternative to mass spectrometry is NMR, nuclear magnetic resonance spectroscopy. The advantage of NMR is that the analysis is absolute quantitatively, and shows a high degree of reproducibility, but the method has relatively low sensitivity and relatively few metabolites have been detected.

The needs of users are increasing, in terms of access to infrastructure, analytical competence and practical knowledge within metabolomics. There is a major technical challenge involved in creating, in a reproducible way, quantitative profiles of thousands of metabolites in varying concentrations, for which a known chemical structure is often lacking. Moreover, areas such as the handling of data, normalisation and linking to other types of data require both specific hardware and software, and also great competence within these areas.

Description: Metabolomics (sometimes called metabonomics or metabolite profiling) is today an integrated part of biological and medical research, and entails identification and analysis of small organic molecules (metabolites) in biological samples. Metabolomics data are necessary to fully understand biological processes and mechanisms. The metabolites provide important biochemical information that can be associated with specific phenotypes or disease conditions. The data analysis requires specialised hardware and software, and a high level of competence in the area.

The methods and techniques used for different types of biological samples are similar, but not identical. There are currently a number of specialist laboratories

established as platforms at Swedish universities. A national infrastructure for metabolomics should include applied techniques, methodology development and leading-edge competence that are coordinated for better accessibility for users from differing research fields and business.

Expected results: Opportunities to combine different metabolomics data are expected to generate an increased number of identified metabolites, which in turn can result in increased knowledge about diseases, improved diagnostics and follow-up of therapies. With knowledge about biochemical patterns that can be linked to physiology or pathology, possible drug targets, for example, can also be identified. An important application area for metabolomics is therefore clinical trials, where metabolic profiles are measured to find new biomarkers for diagnosis or therapy follow-up.

Infrastructure for visualisation of data

Challenge: Growing data volumes from different sources in most research fields have led to a need among researchers to visualise complex and multi-dimensional connections in order to understand, interpret and conduct analyses and draw conclusions. Big data are currently generated by simulations, laboratories, empirical experiments, surveys, crowdsourcing, registers and archives, and may cover areas such as geodata, medical imaging, 3D movement patterns, meteorology, astronomy, geography, archaeology, or history. These data are complex, often multi-dimensional and include a lot of white noise. Analyses of complex data are many-faceted and may include patterns, abstract relationships and development of phenomena over time and space. As data, users, suppliers and experts within implementation of visualisation exist within different organisations, access to and provision of visualisation should be broadly available, useable and include user support.

Description: Visualisation is computer-supported development of visual representations of data, aimed at increasing understanding. Visualisation helps researchers to understand large amounts of complex data in various scientific disciplines, and includes processing and presentation of data in the form of graphs, diagrams, maps, images, or animations, for example. A prerequisite for infrastructure for visualisation of data is collaboration with other existing infrastructures, including e-infrastructures. Improved hardware and software systems and open data have led to the visualisation area growing and expanding to cover more and more methods and types of data and areas, which requires expert support and infrastructure for optimal utilisation within the research community.

Expected results: The infrastructure is expected to promote awareness among researchers of visualisation of data as a research tool within many scientific fields that are today using these methods to a limited extent, for example digital humanities, social sciences, geography, and medicine. Increased use of visualisation in research is expected to lead to greater understanding of correlations and causal relationships in complex datasets, and also to better communication of research findings.

MEDem Monitor for Electoral Democracy in Europe: inclusion in ESFRI's roadmap

Challenge: Many of today's democracies are facing a number of clear challenges. For example, several political elections in recent years have thrown up surprising results. As a well-functioning election system is one of the fundamental pillars of modern democracy, it is of the utmost importance to understand how citizens, parties, media and social elites interact and relate to each other when it comes to the battle for votes. In current-day Europe, it is not enough that a country is studied with consideration for the factors mentioned; instead, as many countries as possible should be investigated and compared over as long a time as possible.

To do this, international infrastructure relating to democracy development and voter behaviour is needed, to coordinate the currently dispersed infrastructures, projects, centres, etc. that handle this type of data.

Description: MEDem (Monitor for Electoral Democracy in Europe) aims to establish, operate and develop a pan-European distributed research infrastructure based in Sweden (University of Gothenburg), and with centres also planned for Denmark, Germany, Greece, France, Netherlands and Portugal. A further 20 or so nodes are planned to be included. The goal of MEDem is to be included in ESFRI's roadmap.

The infrastructure shall enable close collaboration between researchers when it comes to data from national elections and elections to the European Parliament, relating to citizens, political parties, social elites, media, and contextual data. Data components shall also be harmonised, and new and old election surveys be linked and accessible for researchers and society as a whole in a database.

Swedish research in this area is of high international standard, and a coordinated push to join up databases with long time series that enable comparative research into voter behaviour is of great importance for social sciences research.

Expected results: This type of infrastructure would provide added value to both social sciences research (politics, economics, sociology, media science, etc.) and for society as a whole. With an infrastructure such as MEDem, research into elections and representative democracy can be strengthened, both in Europe and in Sweden. As a world-leading nation when it comes to election research and democracy surveys, Sweden is well suited to host an international infrastructure of this type.

National coordination of Swedish research ships

Challenge: Sweden has the longest coastline in the EU. The surface area of the neighbouring seas – the Baltic and the three western sea areas Kattegat, Skagerrak and Öresund – is approximately 450 000 km^2, which is the same as Sweden's land surface. This means that the marine environment is our most common habitat type. Marine observations are increasingly carried out by autonomous systems, but research is also dependent on direct access to the marine environment via ships. These are often adapted for research and act as platforms for observations and experiments. The research ships and their instrumentation are currently managed by both HEIs and public agencies, and the coordination between them is often limited. The lack of coordination leads to inefficient use of resources and limits Sweden's ability to take a leading part in international collaborations.

Description: Coordination of existing marine research platforms would both make the operation more efficient and benefit research. The greatest needs are for ships, the measuring equipment they are fitted with, and the relevant support personnel. A national infrastructure within marine research should aim to ensure efficient use of resources and open access to research and data, and to be a joint actor for international collaboration. The infrastructure should also coordinate the development of new technology for marine observations.

The infrastructure should continue building on the existing collaboration that currently exists between HEIs and public agencies, and involve the relevant national operators of marine research platforms. Actors that operate marine platforms for other purposes may be included, on condition that resources are made available for research.

The greatest current need is for coordination of ships and measuring equipment for marine research, support for a joint national prioritisation of ship resources and Swedish researchers' access to them, based on open accessibility in competition. The need is not currently assessed to include investments in new equipment or operating costs for new or existing resources.

Expected results: Joining together Swedish research ships and measuring equipment for marine research under a national infrastructure with responsibility for scientific prioritisation, optimisation of resources and technical development will promote national and international collaboration, and contribute to safeguarding the quality of Swedish marine research. The infrastructure will also contribute to the resources being used in a cost-effective way, and to Swedish marine research institutions being attractive partners in international collaboration. Other expected effects of the coordination are increased quality of Swedish marine education and better information for national and international decision-making in the management of the marine environment.

Swedish membership of Euro-Bioimaging-ERIC

Challenge: Strong technical development of imaging technology is revolutionising biology and medicine through the opportunity to visualise, characterise, and measure molecular and cellular functions with a precision that has never previously been achieved. Biological and medical imaging are central to research within most disciplines of life sciences. The rapid technical development gives rise to needs for ever-more expensive equipment and advanced competence to ensure it is used in the right way. There is growing demand from Swedish researchers for access to advanced imaging technology and competence within the area. Swedish membership of the European research infrastructure for biological and medical imaging (Euro-BioImaging, EuBI or EuBI-ERIC) can contribute to reinforcing Swedish research in this area.

Description: Euro-BioImaging was initiated in 2010 and is in the preparatory stage for becoming an ERIC. Sweden currently has an observer role in the organisation, and is now ready to apply for full membership.

Euro-BioImaging is a distributed infrastructure, with nodes in participating countries and a supporting hub shared between Finland, Italy and the international organisation EMBL. The nodes specialise in different imaging techniques, and are

funded locally and nationally. The available infrastructures include techniques for medical image processing, multi-modal molecular image processing and advanced microscopy methods for super-resolution microscopy, multi-modal light microscopy, functional fluorescence-based microscopic image generation and image analysis, and correlative light and electron microscopy.

Expected results: Swedish membership of Euro-Bioimaging would give Swedish researchers access to advanced techniques for biological and medical imaging and to competence and methodology development in the area, which is currently not available in Sweden. This is important for the quality and competitiveness of research, but also for Swedish medical technology industry and healthcare.

Swedish membership of European Marine Biological Resource Centre (EMBRC-ERIC)

Challenge: Deeper knowledge about marine ecosystems can contribute to fulfilling the UN's goal for sustainable use of oceans and marine resources. Increased access to marine research data and laboratory organisms is needed to create a clearer picture of the state of the ecosystems and better models for their resilience. As for other global issues, international coordination is a prerequisite, and participation at European level is expected to be of great benefit, both for Swedish researchers and for a sustainable approach to ocean and marine resources. In association with this, the opportunities for technology development of benefit to research need to increase.

Description: The European Marine Biological Resource Centre (EMBRC) is a distributed infrastructure, aimed at promoting research into marine organisms and ecosystems through coordination of marine field stations and research institutes. EMBRC has been included in ESFRI's roadmap since 2008, and has been an ERIC since February 2018. Membership gives researchers access to research stations, ships, instruments, laboratories, "omics" platforms and other marine infrastructure across large parts of Europe via a service database. The infrastructure also provides large datasets in the form of metadata, sequences and historical time series, for example.

Expected results: Sweden's marine environments are unique in Europe, as they span a very wide range in terms of salinity, climate and access to nutrients. By making Swedish marine environments accessible, data from these can be placed into a global context, thus increasing the understanding of ecosystems on a large scale. Swedish researchers having access to international infrastructure and competence is expected to increase both the quality of Swedish marine research and the mobility of researchers in this field. The international perspective that membership of EMBRC will provide is expected to contribute to greater understanding of local and global changes in marine environments, and thereby how these are affected by changes in climate. Membership is also expected to entail further strengthening of the collaboration and coordination of Swedish marine research stations.

Swedish participation in European Plate Observing System (EPOS-ERIC)

Challenge: Understanding of the Earth's development and dynamics in order to predict natural catastrophes or safely extract natural resources, for example, is entirely dependent on integrated analyses of data from several observation systems. The systems can be passive, such as seismographs, GPS networks and magnetic measuring systems, or active, such as geophysical measurements that are commonly used within energy and mineral prospecting, but also within research. These are linked to observations from many sources, from entire systems of satellites and drilling platforms to samples obtained using hammer and spade for further analysis in laboratories. These methods generate large amounts of disparate data, which must be accessible in a structured and well-documented way to enable their use for research. Linking together data from several different types of international, national and local observation systems and making them accessible to solid Earth research is a major challenge.

Description: The European Plate Observing System (EPOS) is developing a platform for linking together data about solid Earth from research institutes, public agencies, commercial companies and international collaborations throughout Europe and nearby areas. EPOS has engaged researchers and public agency representatives in the work of developing data standards and modelling tools since the project was included in ESFRI's roadmap in 2008. The work of implementing standards and building up an e-infrastructure platform for data distribution, validation, visualisation and modelling started in 2015. EPOS will be an ERIC as from October 2018.

Swedish researchers and public agency representatives have been actively engaged in EPOS since the start. In addition to pure basic research within areas such as seismology and geodynamics, Swedish interest is great within mineral resources and geodesy.

Expected results: EPOS-ERIC is expected to initiate the creation of complementary and supportive national initiatives, which will eventually also contribute to EPOS-ERIC and thereby give researchers in Sweden and Europe access to a multiplicity of data and models. This gives research the opportunity to address urgent questions relating to geo-risks and access to mineral resources, for example, but also entirely new questions. In addition to giving Swedish researchers access to data and modelling tools, membership of EPOS-ERIC would also enable deeper collaboration between Swedish research institutions, and between research institutions, public agencies and research-focused companies.

Swedish participation in the planning, construction and operation of Aerosols, Clouds and Trace Gases Research Infrastructure (ACTRIS)

Challenge: Both the Earth's climate and human health are affected by aerosols and trace gases in the atmosphere. Climate is affected by the amount of aerosol particles in the atmosphere, as they reflect and/or absorb radiation from the sun, and contribute to the formation of clouds. Human health is affected both by airborne particles and by other air pollutants. To understand the link between human impact and natural processes in the atmosphere and biosphere, long-term quality-controlled and standardised measurements are needed of aerosols, clouds and trace gases. These

have a relatively short lifetime in the atmosphere, from a couple of hours to a few weeks, which means that their concentrations vary more over time and space than more long-lived compounds. High-quality and long-term measurements of aerosols, clouds, and trace gases are therefore needed for increased process understanding and better description in models. To obtain a clear picture of air quality and climate processes, observations need to be made across borders, and observation data need to be open and easily accessible to researchers.

Description: Operations where aerosols, clouds and trace gases are observed and studied are coordinated within the framework for the European initiative Aerosols, Clouds and Trace Gases Research Infrastructure (ACTRIS). ACTRIS is a distributed infrastructure that has been included in ESFRI's roadmap since 2016, and is now an H2020 Preparatory Phase Project. ACTRIS is expected to be fully operational in 2025.

The infrastructure collects data on physical, optical and chemical characteristics of short-lived compounds in the atmosphere, and the prevalence of clouds in time and space. ACTRIS aims to increase the efficiency of research in its field, by offering researchers a joint platform with facilities, technical support, and education of users. The infrastructure also has a database with entirely open, quality-controlled, and standardised observation data.

Expected results: Through coordinated collection and the entirely open access to observation data, ACTRIS can contribute to the understanding of environment and climate through increased process understanding and better parameters for climate and air quality models. Reliable data on air quality are also of benefit to environment monitors and decision-makers. Sweden can contribute with its specific data to ACTRIS, and Swedish researchers could get access to the infrastructure, including data from other countries.

Swedish participation in ACTRIS would be a complement to existing infrastructures, such as ICOS and SITES. Co-location and coordination with one or several of these is desirable, as this should lead to integrated measurements and thus to better understanding of links between the biosphere and atmosphere, including effects on climate caused by aerosols, such as cloud formation and scattering and absorption of light. Clear added values from co-location and coordination are expected, not just scientifically but also logistically.

Swedish participation in Square Kilometre Array (SKA)

Challenge: Astronomical research focuses on observing and understanding our universe, and its origin and development. Radio astronomy studies astronomical phenomena with the help of radio telescopes. The next generation of radio telescopes is expected to address important scientific questions, such as mapping the re-ionisation epoch of the universe when the galaxies were formed, finding limitations to the state equation of dark energy, and monitoring the development of gas and magnetic fields in galaxies. The hope is to also use observations of pulsars to test gravitation theories and to detect very low-frequency gravitational waves.

Description: Square Kilometre Array (SKA) is an international radio astronomy project, which is at the planning phase and is included in ESFRI's roadmap. It will consist of a number of linked radio telescopes in South Africa and Australia, which

will be constructed in phases. The first phase, SKA-1, is expected to be completed in the mid-2020s, and will have 15–20 per cent of the final collecting area of the whole SKA. Despite its limited area, SKA-1 will have considerably improved sensitivity compared to today's radio telescopes. In addition, SKA-1 will be able to conduct considerably faster measurements of the sky than existing radio telescopes.

SKA is currently organised as a British limited company, with twelve member countries including Sweden. An inter-state organisation is expected to be formed shortly, which will construct and operate the telescope.

Expected results: SKA has a broad scientific programme, and is expected to contribute with answers to many of the topical questions within astronomy, astrophysics and cosmology. Sweden has long held a strong position within radio astronomy research, which would be further reinforced through Swedish participation in SKA. There are also good prerequisites for industry contacts with Swedish companies within strategically interesting areas, such as data management, renewable energy, radio antennae and receivers.

Upgrade of IceCube

Challenge: Research within astroparticle physics with neutrinos aims to study high-energy neutrinos – a type of difficult-to-detect elementary particles – and their astrophysical sources. As neutrinos are not deflected by magnetic fields and only interact weakly with matter and radiation, they constitute unique messengers of information from the universe, and can be used to study the origin of high-energy cosmic radiation in supernova remains and starburst galaxies, for example.

Description: IceCube Neutrino Observatory is a neutrino telescope at the South Pole, consisting of light-sensitive detectors placed deep inside the Antarctic ice, with a total volume of around one cubic kilometre. IceCube has discovered neutrinos of astrophysical origin, but has not yet been able to link them to specific sources.

An upgrade of IceCube would consist of two parts. The first part aims to increase the space resolution for detection of high-energy neutrinos. This would be done by densifying the lines of optical detectors in the inner, lower part of the telescope with seven new detector strings with improved detectors. Such densification would dramatically increase the chances of identifying the sources of the detected particles. It would also enable studies of the characteristics of neutrinos, such as mass hierarchy and measurements of the most massive neutrino, the tau neutrino.

The second part of the upgrade aims to measure signals from ultra-high energetic neutrinos, which have long been predicted, but so far never observed. This would be done with the help of radio antennae, located on the ice surface.

Expected results: The upgrade of IceCube would open the door to research into a number of topical questions within neutrino-astroparticle physics. The upgrade would also improve the calibration of the telescope, which would make it possible to conduct new, more precise analyses of the data previously captured by IceCube during the decade the telescope has been in operation. Sweden is also expected to contribute to and benefit from the development work related to the upgrade, within areas as widely differing as advanced radio technology and wind turbines, which are a consequence of the need for energy to drive the experiment.

A2
Relevant for consideration as infrastructure of national interest, but funding currently not prioritised by the Swedish Research Council

Access to large-scale facilities for neutrons

Challenge: Neutron scattering techniques are important within a number of different areas, such as materials sciences, chemistry/chemical engineering, and physics, and can contribute to increased knowledge within both basic and applied research, including industrial/industry-related projects. Swedish neutron scattering needs to be strengthened in order to become competitive for beam time at ESS in Lund, for example. Today, Sweden has a strong and growing user base within neutron scattering techniques due to an increase both in the number of users and the range of application areas. Ahead of the start of ESS around 2023, it is desirable that this development continues, and that the user community continues to broaden and increase in numbers. Access to experiment time is a crucial factor, but in order to also be part of developing techniques and leading the technology development, Swedish researchers need to take part in the development and operation of instruments at the facilities that are currently operational. It is therefore of strategic relevance to make sure Swedish research teams are involved in the development of infrastructures related to neutron scattering at today's facilities.

Description: Structured national access to large-scale facilities for neutrons would fill both a coordinating and an educational function in the Swedish research landscape. It is of importance that Swedish researchers are offered continued access to ILL in France and ISIS in the United Kingdom, in the first instance within the technology areas that will be available at ESS. Moreover, strategic participation in instrument development projects at existing international sources may be valuable for ensuring competence to enable participation in, or even managing, future instrumentation projects at ESS as part of Swedish in-kind funding. In addition, direct engagement in instrumentation is a basis for competence build-up and an opportunity to educate junior researchers. It is the Swedish Research Council's assessment that initiatives of this kind should be put into their context as part of the national ESS strategy.

Expected results: The proposed structure could provide many positive results, such as increased competence within the neutron scattering community – something that is most important for younger future users of ESS – and show greater returns in terms of good research from the investments being made nationally within the neutron scattering field. If one infrastructure is to fulfil the national interest in neutron scattering, it is however important that the content becomes relevant for the whole of Sweden's research community within the areas in question, and not just for those research teams that are already active neutron users or instrument developers. In-depth information initiatives are needed to make Swedish researchers and business users that are currently not using neutron scattering techniques aware of the opportunities the methods at ESS can offer them.

Infrastructure for cultural heritage and digitisation

Challenge: Swedish cultural heritage has long been digitised by memory- and research institutions, but is in need of a joint national infrastructure and platform to offer access to the digitised material, and to preserve and explore it. Research questions within humanities often require the researcher to have access to large amounts of cultural heritage data in digital form – nor just rich meta-data for the objects, but also high-quality digital reproductions in the form of marked-up full text transcriptions, contextual information and, not least, digital facsimiles. The competence and resources for digitising, storing, and making openly accessible cultural heritage material to research and the general public vary greatly from one memory institution to another, and the need for a joint national infrastructure is great and urgent.

Description: A national infrastructure within cultural heritage and digitisation shall aim to ensure efficient use of resources and open access to research and data. Cultural heritage digitisation is currently handled in a collaborative programme between the Swedish Research Council, Riksbankens Jubileumsfond and the Royal Swedish Academy of Letters, History and Antiquities, with a call for research project grants for digitising and making accessible cultural heritage collections. Within the framework for the programme, a total of 125 million SEK will be made available over the next few years to researchers within these fields. This investment may be able to help define national initiatives that are clearly justified in the future.

Expected results: A national infrastructure for digitising cultural heritage is of relevance for several research fields, primarily within humanities, but also within social and natural sciences. As Sweden is a small linguistic area that has not been covered by major international digitisation initiatives (such as Google Books) other than through collections of Swedish language material in foreign libraries, such an infrastructure would contribute to making visible and strengthening research into Swedish cultural heritage material in subjects such as linguistics and history. The infrastructure would also offer tools for researching and creating added value within and between the digital cultural heritage collections. From a user perspective, the time for collection, preparation, and analysis of the data could be reduced significantly. Furthermore, interest from fields such as computer science in collaborating with humanities to use digital cultural heritage data is increasing, in particular within the growing area of digital humanities. A national infrastructure for Swedish digitised cultural heritage material would support documentation, preservation, access, methodology development, and investigation of Swedish cultural heritage on a broad humanities basis.

Instrumentation at MAX IV

Challenge: The MAX IV facility in Lund was opened in summer 2016, and produces world class synchrotron light. The laboratory has become a model for most new synchrotron light facilities and upgrades of existing facilities planned around the world. MAX IV currently has 16 beam lines funded, but there is space for at least 10 further beam lines. The new beam lines should enable researchers to conduct highly qualified experiments, and preferably support research fields that are or have the potential of becoming world leaders. This means, for example, using the unique characteristics of MAX IV's beams, such as their low emittance, the very high degree of coherence and the option of small beam diameters. The prioritisation of future beam lines is of national strategic interest.

Description: In 2017, the Swedish Research Council decided to continue supporting MAX IV. The grant relates to the operation of the facility and the commissioning of the 16 beam lines that have now been completed. The Swedish Research Council is not currently planning to invest in further beam lines, but welcomes other funding bodies to do so. More beam lines have been proposed by the Swedish user community, such as DiffMAX, a hard X-ray beam line for diffraction and photoelectron spectroscopy, and MIRARI, a beam line for microscopy and infrared and rapid imaging spectroscopy. Furthermore, instrumentation development initiatives have been proposed for the use of a potential free electron laser in the soft X-ray area (SXL). Every one of these needs has been assessed as urgent. It is the task of MAX IV, in consultation with the stakeholders involved, including other Swedish HEIs and stakeholders in other countries, to prioritise which further beam lines should be constructed.

Expected results: A strategically anchored expansion of the beam line park at MAX IV will significantly increase the value of the facility as a producer of world-leading research within fields as disparate as materials sciences, engineering, physics/chemistry, biology/medicine, palaeontology and archaeology.

A3
Relevant for consideration as infrastructure of national interest, not ready for call 2019

Digital infrastructure for historical locations

Challenge: There are today a large number of Swedish knowledge banks with historical source material that are unique in international comparison, in terms of scope, level of detail, and age. Even if these are largely digitised and form the basis for a number of research projects, the data that exist are under-utilised. One of the reasons for this is that the databases are not constructed in a way that enables combined use of the data they contain. The lack of coordination also means that analyses and new questions have to take second place to data collection. By linking historical databases to geographical units, the problems mentioned could be solved, and also give rise to a national standard for historical research data in Sweden.

Description: An infrastructure based on coordinate-defined registers that define locations in historical time is of relevance for several research fields, primarily within humanities, but also within social and natural sciences. Today's knowledge banks with historical source material contain data that are all linked to geographical locations. By using "geo-coding", links are created between different historical databases, which can give rise to new questions and not least to broader (multi-disciplinary) and more efficient use of the database contents. The user base could be widened, as the linking envisaged allows historical data and sources to be discovered without any need for knowledge of every archive or system included in the infrastructure. The infrastructure that here relates to a distributed database could form a new foundation for future research, in particular within the historical field. To safeguard the estab-

lishment of such an infrastructure, broad acceptance must exist throughout the entire field of archive sciences, library and information sciences, and museology.

Infrastructure for artistic research data

Challenge: Existing storage places for research data have insufficient support for documentation, preservation, presentation, and dissemination of artistic research data, which therefore risk remaining under-utilised. The need for this type of infrastructure is obvious, and should stimulate research fields within humanities and inter-disciplinary collaboration in particular, as well as opening the door to collaboration with society as a whole. However, the production of an implementation plan that clarifies how the need can be satisfied in an infrastructure is still lacking, and the infrastructure also needs to be positioned in relation to DIVA and SWEPUB.

Description: For artistic research, the way of presenting research results is very important, and traditional formats for research data are not designed for this research field. The most prominent solution at international level is offered by the Society for Artistic Research (SAR) through its Research Catalogue (RC), which provides an open platform for artistic research data. On the other hand, there is no Swedish research infrastructure for documentation, dissemination, publication, and archiving of artistic research using RC as the basis. An infrastructure for artistic research data needs to serve as an intermediate storage place between national research databases and databases at individual HEIs.

Infrastructure for biomedical imaging

Challenge: Biomedical imaging is of great importance for both clinical and pre-clinical research. It is an important feature of neurosciences, neurology, cardiology, oncology, metabolic diseases and pharmacodynamics. One of the challenges of Swedish research is to produce and maintain ultramodern equipment and competence in various locations in the country, in order to guarantee clinical and pre-clinical development and new diagnostic methods.

Description: Biological/medical imaging includes techniques such as computer tomography (CT), magnetic resonance tomography (MR) positron emission tomography (PET) and single-photon emission computed tomography (SPECT). Technological advances have recently been made in this area, in terms of improved resolution, functional contrast, and new trace molecules. These technical advances can be improved further by integrating different platforms to combine results and share knowledge. It is important that existing equipment within the country is made accessible to all users.

Integration into a national infrastructure of the technology and competence mentioned above, as well as other types, can increase the scientific returns and thereby help to clarify the mechanisms for how humans, animals, and organs function. To fulfil the criteria for a national infrastructure, collaboration must improve between different platforms and also their management structures. All these methods require good e-infrastructure, which could also be managed jointly by the proposed infrastructure.

Infrastructure for digital archaeological analysis and visualisation

Challenge: There is a clear need within Swedish research for a national infrastructure for digital archaeology, with capacity to handle, analyse, and make accessible multi-disciplinary research results. Such an infrastructure would be of great importance for the development of Swedish research within humanities and social sciences. For an infrastructure of this type to be developed, actors with sufficient capacity and knowledge need to formulate clearly how the infrastructure should be built up and organised.

Description: Sweden has a long and successful history within archaeology in terms of enabling data collection and storage. The primary purpose of the proposed infrastructure is to develop digital methods for handling, analysing, and disseminating research results from projects with large data amounts from a number of disciplines. The aim is to create a basis for better understanding of the complexity of and changes to societies over a long time.

Infrastructure for electron microscopy for materials studies

Challenge: Advanced materials are of central importance for our civilisation, and new types of materials, good material functionality, and better manufacturing processes are some of the key factors for achieving a more resource-effective and energy-balanced society. The characteristics of a given material are dependent on its structure (at different length scales), chemical composition and the resulting atomic bonds. Transmission electron microscopy (TEM) is a powerful technique for studying the structure and characteristics of different materials, and thereby contributes to solving questions within materials sciences, but also within fields such as physics and chemistry. The technique is currently available at all Swedish HEIs, and within these at most departments. The instrumentation ranges from standard instruments for routine measurements to high-end instruments. There is, however, a need for a joint infrastructure for electron microscopy, with broad support from the HEIs that are developing and making the technology accessible.

Increased coordination of the Swedish advanced electron microscopy use would potentially be of great value, both to further develop the existing instrument configuration, but also in order to better utilise the investments that have already been made. Further work is necessary, however, to develop a clear model for how the infrastructure is to be shared and operated, and how it can serve researchers from differing disciplines.

Description: Many of Sweden's researchers (materials scientists, physicists, chemists, etc.) have a large and broad need for access to advanced electron microscopy methods. A national distributed infrastructure would enable more efficient access to the resources that are currently distributed across HEIs, through a transparent application procedure. Furthermore, major developments have recently occurred within the electron microscopy area. A national infrastructure that could make top instruments accessible to Swedish researchers would open the door to new research opportunities within a number of disciplines, and contribute to increased mobility between HEIs. In the design, there are however several aspects that need to be included to clearly describe the role of a national infrastructure in relation to what is necessary instrumentation for a local infrastructure for research and education at each HEI.

Infrastructure for humanities laboratories

Challenge: The need is great for a national infrastructure for humanities laboratories (Humlab) at Swedish HEIs. Such an infrastructure would create added value over and above what individual laboratories are currently able to do, and would be of great importance for the development of Swedish humanities research. There is still a need for deeper coordination between existing actors to strengthen the research and clarify the added value of a national infrastructure for Swedish research. Humlab could, for example, collaborate to create added value in such an infrastructure; an added value that would then be greater than what each individual actor is able to create, and that is formulated on the basis of national relevance, and not that of the HEI/region.

Description: Humlab operates within the broad field known as digital humanities. Digital humanities can be understood in different ways, but central features are critical humanities studies of digital phenomena, and also the use of digital tools and methods in the study of questions within humanities research. Digital humanities also concern the use of digital media within teaching in various ways. Humlab plays an important role in this. For example, it can host advanced sensor instruments with research-competent personnel responsible for the equipment, or provide support with calculation resources to handle data, or administrative and technical support to researchers within the broad field of digital humanities.

Infrastructure for laboratory archaeology

Challenge: The need is great for an infrastructure that gathers together archaeological laboratories into a national resource. Such an infrastructure would be crucial for the development of Swedish research and education within the field. Laboratory archaeology is an inter-disciplinary field. Over the last few years, methodology and theory development within the area has been very comprehensive, and Swedish research is ground-breaking in several areas. It is crucial for continued successful research within the field that access to knowledge, infrastructures, and quality-assured analysis methods and support is maintained. To establish a national infrastructure within the area, the added values that the infrastructure would entail must be described clearly. There is currently a consortium of existing laboratories with the potential to develop an infrastructure. As the need for Swedish laboratory archaeology is great, it is important that the archaeological research laboratories focus on creating a joint national research infrastructure.

Description: ArchLab Consortium is a collaboration between archaeological laboratories in Sweden. Together, these laboratories have high capacity and overall competence within a broad spectrum of analysis methods, such as archaeobotanics, palaeoentomology, land chemistry, archaeometallurgy, dendrochronology, ceramic studies, lipid analysis, etc. Together, they also have a great ability of converting analysis results into interpretations relevant for the inter-disciplinary field of laboratory archaeology.

Infrastructure for marine research and innovation

Challenge: Sweden has five major marine field stations. The infrastructures that these stations manage constitute the basis for data collection for coastal marine research, and for experimental marine research. The stations are operated by various principals, and today lack any national coordination corresponding to what exists for terrestrial research stations through SITES. Swedish platforms for marine research and environmental monitoring have been evaluated repeatedly since the 1990s, by bodies including the Swedish Research Council. A common feature of the evaluations is that they have indicated the need for coordination – both between the research principals and between research and environmental monitoring. The challenge consists of coordinating Sweden's station-based marine infrastructures – research stations, measuring platforms and experimental facilities – to increase accessibility and quality, and to improve the opportunities for comparative studies.

Description: There are many good arguments for coordination, based on cost-effectiveness, increased quality and accessibility to the platforms, as well as the need for knowledge about the marine environment. Several measures have already been taken, among them a reallocation of responsibility between public agencies and the creation of the Swedish Institute for the Marine Environment, to provide a coordinated and scientifically-based basis for management of the marine environment. There is still a need for deeper coordination between the actors to strengthen the research. It is important that the various actors focus on creating an overall national research infrastructure, using open access and cost-effective solutions as the starting point, and based on the collected Swedish marine research community's prioritisations, similar to what organisations such as SITES, SNIC and Myfab do towards their respective user groups.

Infrastructure for nuclear magnetic resonance

Challenge: Nuclear magnetic resonance (NMR) is a well-used technology in many different fields of research: from biology, chemistry, medicine, and physics to environmental research. NMR instruments are used by several hundred Swedish researchers, and are available at many HEIs and within industry. The area of use ranges from very advanced and development-driven research to more standardised use for many applications.

Description: A national infrastructure for NMR may consist of several different specialised nodes that are accessible to a large number of users from many HEIs, as well as to users from business or the public sector. The design of a national infrastructure for NMR should be based on a clear strategy and well-balanced prioritisations. The long-term aim is to have a national NMR infrastructure that provides prerequisites for world-leading research within several areas and can meet the needs of a large number of users from HEIs as well as from the private and the public sectors.

The need for a national NMR infrastructure is strategically relevant, and could provide great returns in terms of research that uses the instruments that are available at the country's various HEIs. There are, however, several aspects that need to be included in the design, to clearly describe the role a national infrastructure would have in relation to what is necessary instrumentation for a local infrastructure for

research and education at each HEI. A national infrastructure that could make top instruments accessible to Swedish researchers would open the door to new research opportunities within a number of disciplines, and contribute to increased mobility between HEIs.

Infrastructure for protein production

Challenge: Characterisation and use of proteins to understand biological and physiological processes is of central importance to research within life sciences. For example, the development of medicines is dependent on access to high-quality protein products. It is often technically difficult and time-consuming to produce proteins, and there is a need for more efficient and more reliable protein production. In Sweden, structural biology is a prominent research field that is expected to expand further via the platforms Cryo-EM and NMR for Life, as well as the major infrastructure investment MAX IV and the future ESS in Lund. A prerequisite for protein studies within these platforms is access to pure proteins and tailored structural motifs. Today's challenge lies in matching the growing demand through varied and high-quality protein production. A national infrastructure for protein production with leading-edge competence within the areas in question would therefore strengthen Swedish life sciences.

Description: There are already several platforms for protein production, where either bacteria, insect cells or other eukaryotic cells are used as producers. It could be strategically valuable to integrate these platforms into a national infrastructure, and make them open to users throughout the country. However, clarification is needed regarding the added value of integrating the various platforms for protein production, how to achieve suitable management, suitable solutions for e-infrastructure and links to business, and also more specific answers to how protein production can strengthen research. As three separate proposals were received in the needs inventory, it is apparent that the coordination of the nodes is still unclear and more planning is needed. It is also important to illuminate how the Swedish infrastructure will compete with or complement similar European infrastructures in order to determine whether a separate Swedish infrastructure is needed.

It is important to achieve close collaboration between the analytical platforms mentioned above as well as platforms for medicine development, and this may need formalising. This could benefit a number of research fields within life sciences, which in turn could lead to new biological mechanisms being identified, ideas for new medicines being generated, and new diagnostic procedures being created.

Infrastructure for single cell analysis

Challenge: A population of cells can have a high degree of heterogeneity, and individual cells can also change over time and dependent on signals from its surroundings. Studies of individual cells can therefore be necessary, for example to understand various disease mechanisms and thereby to contribute to improved clinical diagnostics, or to map bacterial ecosystems within environmental research. This has led to rapid development of techniques and methods for so-called single cell analysis, where the behaviour of each individual cell is studied and can be followed over time.

The instruments needed for these analyses are generally very expensive, and the technique is developing rapidly. As single cell analysis is a new research field, only a few researchers currently have the competence needed. A national platform with specialised knowledge within different types of single cell analysis would entail increased efficiency and contribute to quicker development of the methodology through knowledge transfer.

Description: Within SciLifeLab, a platform for single cell biology has been established, with facilities in Uppsala, Stockholm and Linköping. The platform currently offers support to researchers in Sweden. The facilities within the platform also collaborate to further develop the techniques, and to create calculation tools for the data analysis required to fulfil the specific challenges involved in measurement at single cell level. Any added value from organising the nodes into a national infrastructure needs to be clarified, and also what the various facilities would contribute to a joint infrastructure.

Infrastructure for studies of dark matter

Challenge: Dark matter is assumed to constitute around 85% of all matter in the universe, and is a necessary component for explaining a number of astronomical phenomena, such as the behaviour of galaxy clusters, structure formation in the early universe and gravitational lensing. Despite this, so far we do not know what dark matter consists of, and it cannot be explained using the standard model of particle physics.

Description: The search for dark matter is taking place in parallel within several different parameter areas; the candidates for dark matter are either massive or ultra-light. The massive candidates can be divided up into the particles that interact with weak force ("WIMPs"), and those that interact with a so-far unknown force ("hidden sector dark matter"), which may be lighter and exist in the same mass area as the known matter. WIMP-based research within dark matter is conducted at LHC at CERN and Laboratori Nazionali del Gran Sasso (LNGS) in Italy among others, but access to experiments focusing on hidden sector dark matter is almost non-existent. Experiments that are sensitive to dark matter in the same mass area as known matter are lacking in particular. Research within the areas is complementary, but prioritisation of the Swedish initiatives is currently lacking.

Instrumentation for fundamental physics at ESS

Challenge: ESS, the European spallation source for neutron production under construction in Lund, is an international facility where Sweden has made considerable investments. The first neutrons for use in experiments are planned for 2023. In the initial set-up of instruments, there are no plans for the study of fundamental physics, but ESS's management has expressed a will to involve the nuclear and particle physics communities in a future fundamental physics programme at ESS. The parameters at ESS, primarily the planned very high neutron flow, would make certain types of previously impossible particle physics experiments that can potentially be implemented at the facility.

Description: An infrastructure that establishes a new experiment at ESS for fundamental physics would be of great value. Such a measurement could, for example, involve neutron-antineutron oscillations. Scientifically, this involves fundamental physics relating to baryon number breaks, matter-antimatter, dark matter, physics beyond the standard model, etc. Such an instrument at ESS could form a national node for hadron physics in Sweden, and naturally complement other international engagements, such as FAIR and ALICE. It is strategically important that a fundamental physics experiment at ESS clearly utilises the unique aspects of ESS. Experiments that could be implemented at other, already existing facilities should however not be part of ESS's future instrument suite.

Although exploiting ESS for fundamental physics is well in line with Swedish research priorities, it should be taken into account that ESS is still under construction, both in terms of the facility and the initial set of instruments. Proposals for new instruments, for example for fundamental physics, will be collected and assessed starting from 2019 and onwards.

Space Environment Centre

Challenge: Instruments and components to be used in the upper atmosphere and space must be well adapted to the conditions that prevail there. Optimisation of instruments, components and materials can, however, not easily be carried out on site in these hard-to-reach environments. To allow iterative adaptations of hardware and other necessary tests, ground-based facilities are therefore needed, where conditions in space and the upper atmosphere can be realistically simulated. Researchers currently have access to infrastructure for these purposes, but the facilities are geographically and organisationally spread out, which makes the procedure for access difficult and waiting times long. A joint infrastructure would therefore be of benefit, and would also provide opportunities to test more environmental variables simultaneously than is possible in the current wide-spread system.

Description: A joint infrastructure to support Swedish space research – both basic research and innovation – with design, testing, calibration, and certification of hardware. The infrastructure would form a foundation for the development of space-based instruments and components, via ground-based experiment and simulation facilities, where factors such as temperature, pressure and radiation can be varied. The focus is on physical simulation of environments outside the Earth's atmosphere and in its upper parts, but there would also be opportunities for in silico design and simulation. The infrastructure would have comprehensive competence within the area, with experienced personnel providing support to users.

To establish a national infrastructure within this field, possible added values of gathering together facilities and competences must be thoroughly investigated. This includes concrete information on broad support from both the space industry and the research community. The interest and involvement of the Swedish National Space Board in this infrastructure should also be clarified.

Upgrade of DESIREE

Challenge: DESIREE (Double ElectroStatic Ion Ring ExpEriment) is used for studies of individual reactions with ions in well-defined quantum states. DESIREE

is the only infrastructure of its kind, where for example interstellar ion-ion interactions can be investigated at the temperatures that prevail in the environments where they exist. An upgrade of DESIREE could broaden the range of ions that could be studied at the facility, make it possible to select molecular ions with specific conformations, make molecular ions colder than is today possible – for example by storing them in nanodrops of helium, or by making the ring itself colder and significantly improve the characteristics and life of the ion beam. The sensitivity of the detectors could also be improved, which would shorten measuring times.

Description: DESIREE consists of two ion storage rings, where two ion beams overlap and where reactions between individual pairs of ions can be studied in detail. In addition to studying reactions between different types of ions, inherent characteristics of these systems can be studied with the help of advanced lasers. Using DESIREE, processes within fundamental nuclear and molecular physics can be studied, with applications within areas such as astrophysics, atmospheric physics, and biomolecular physics. The research is focused on stability issues and slow decay of positive or negative ions of atoms, molecules or atom clusters, photo-absorption spectroscopy of cold ions, reactions between individual pairs of positive and negative ions, fragmentation and reaction dynamics and studies of the characteristics of biomolecular systems in vacuum and in solution.

A consortium consisting of Stockholm University, University of Gothenburg and Malmö University operates DESIREE as a national infrastructure at Stockholm University. However, DESIREE is still a relatively new national infrastructure and a larger basis of scientific results is needed before an upgrade can be considered justified.

Upgrade of SITES for membership of AnaEE and eLTER

Challenge: To meet today's societal challenges within climate and environment and achieve the global sustainability goals, improved capacity for ecosystem experiments and an increased level of international collaboration is needed, as issues relating to climate and environment usually are global. Field-based ecosystem research that covers and links together different habitat types is necessary to establish causal relationships in complex environments.

Sweden has the opportunity to contribute habitat types and climate zones that are unique in a European perspective, and the national infrastructure Swedish Infrastructure for Ecosystem Science (SITES), with field stations distributed across large parts of Sweden, is already well established. Linking SITES to European networks could increase the use of the infrastructure further, and provide more opportunities for international collaborations within ecosystem research.

Description: Analysis and Experimentation on Ecosystems (AnaEE) is a distributed infrastructure that has been included in ESFRI's roadmap since 2010, and is expected to become operational as an ERIC in 2018. The purpose of AnaEE is to manipulate ecosystems to understand how these respond to changes in factors such as climate and land use. The European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER) is also a distributed infrastructure for ecosystem research. It is included as an "Emerging Project" in ESFRI's roadmap from 2016. Here, the focus is on better understanding the structure and function of ecosystems,

and how they respond to environmental, social and economic changes that occur around them over time.

Swedish membership of AnaEE and/or eLTER could require upgrades and other changes to existing national infrastructure. If so, what this would entail needs to be clarified.

Research infrastructures funded or previously funded by the swedish research council

A brief description of all research infrastructures funded by the Swedish Research Council can be found on www.vr.se. Research infrastructures currently funded by the Swedish Research Council, for which the grant period terminates in 2019 or 2020, are authorised to apply for infrastructure grants in the 2019 call.

Research infrastructures funded by the Swedish Research Council

The following research infrastructures are currently funded by the Swedish Research Council. Those authorised to apply in the 2019 call are marked with asterisks. The terms and conditions that apply for each focus area will be stated in the call.

BBMRI-ERIC – Biobanking and Biomolecular Resources Research Infrastructure
*BioMS – a national infrastructure for biological mass spectrometry
*BIS – Biobank Sweden
CERN – European Organisation for Nuclear Research
- Alice
- Atlas
- Isolde
- WLCG

CESSDA-ERIC – Consortium of European Social Science Data Archives
Clinical Studies Sweden
CORS – Comparative Research Center Sweden
DESIREE – Double ElectroStatic Ion Ring ExpEriment
*EATRIS-ERIC – European Advanced Translational Research Infrastructure in Medicine
EGI – European Grid Infrastructure
EISCAT (EISCAT-3D) – European Incoherent Scatter Scientific Association
EMBL – European Molecular Biology Laboratory
ESO – European Southern Observatory
- Alma
- *E-ELT – European Extremely Large Telescope
- VLT

ESRF – European Synchrotron Radiation Facility
ESS – European Spallation Source
ESS-ERIC – European Social Survey

EUI – European University Institute
FAIR – Facility for Antiproton and Ion Research
    *AGATA
    Nustar
    Panda
    SPARC/APPA
GBIF – Global Biodiversity Information Facility
IceCube – neutrino telescope
*ICOS-SE and ICOS-ERIC – Integrated Carbon Observation System
ILL and Super-Adam
*Infrastructure for integration and accessibility of data within biodiversity informatics: Swedish LifeWatch/Biodiversity Atlas Sweden
Infrastructure for register-based research, and RUT (Register Utiliser Tool)
IODP/Ecord – Integrated Ocean Drilling Programme
*Ion Technology Centre
*ISF – Institute for Solar Physics
ISIS Neutron Spallation Source
    HRPD
    IMAT
    Polaris
ITER and EUROfusion
MAX IV laboratory
MONA – Microdata On-Line Access
*Myfab – Swedish cleanroom network
*NBIS and Elixir – National Bioinformatics Infrastructure Sweden
NEAR – National E-Infrastructure for Ageing Research
NeIC – Nordic e-Infrastructure Collaboration
*NGI – National Genomics Infrastructure
*NMI – National infrastructure for microscopy within life sciences
*Nordsim/Vega laboratory
NOT – Nordic Optical Telescope
Onsala Space Observatory and JIVE (Joint Institute for VLBI-ERIC)
Petra III – synchrotron light facility at the DESY laboratory
PRACE – Partnership for Advanced Calculations in Europe
REWHARD – RElations, Work and Health across the life-course – A Research Data infrastructure
Riksriggen – scientific boring
SHARE-ERIC – Survey of Health, Ageing and Retirement in Europe
SIMPLER – Swedish Infrastructure for Medical Population-based Life-course and Environmental Research
SITES – Swedish Infrastructure for Ecosystem Science
SKA – Square Kilometre Array
SND – Swedish National Data Service
SNIC – Swedish National Infrastructure for Computing
Språkbanken, SWE-CLARIN and CLARIN-ERIC – Common Language Resources and Technology
STR – Swedish Twin Register
SUNET – Swedish University data network
SWEDPOP – Swedish population databases for research
UGU – Evaluation Through Follow-up
XFEL – X-ray free-electron laser

Research infrastructures that have previously been funded by the Swedish Research Council and are regarded as infrastructures of national interest

Major investments in infrastructure, that is grants for equipment or collection of data funded by the Swedish Research Council, are normally depreciated over 3–5 years. However, the infrastructure is normally of value to Swedish research over a considerably longer time than this, and shall therefore continue to be usable for researchers in competition.

Additional grants

In addition to the infrastructures listed above, grants may also be applied for to fund increased Swedish engagement in international infrastructures in which Sweden is already participating. Additional grants refer to costs for clearly delimited Swedish scientific activities, such as calls for contributions in kind or similar, where Swedish researchers intend to participate and therefore need additional grants.

The Swedish Research Council has a model of prioritisation of research infrastructure that is based on a two-year cycle. In the first year, an inventory of needs of research infrastructure in Sweden is conducted with the purpose to identify new national research infrastructure needs. The outcome of the inventory is used as the basis for the Swedish Research Council's targeted call for funding of research infrastructure of national interest; the call is held in the second year of the cycle.

During the inventory of needs conducted by the Swedish Research Council in 2017–2018, just under 100 proposals were received from higher education institutions, public authorities with research responsibilities, funding bodies, and research groups.

All incoming proposals for research infrastructure were assessed in terms of scientific, strategic, and national value, as well as feasibility.

In this report we describe the thematic areas that were found to be of the highest scientific and strategic value.

The report is an appendix to the Swedish Research Council's Guide to Infrastructure 2018.

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