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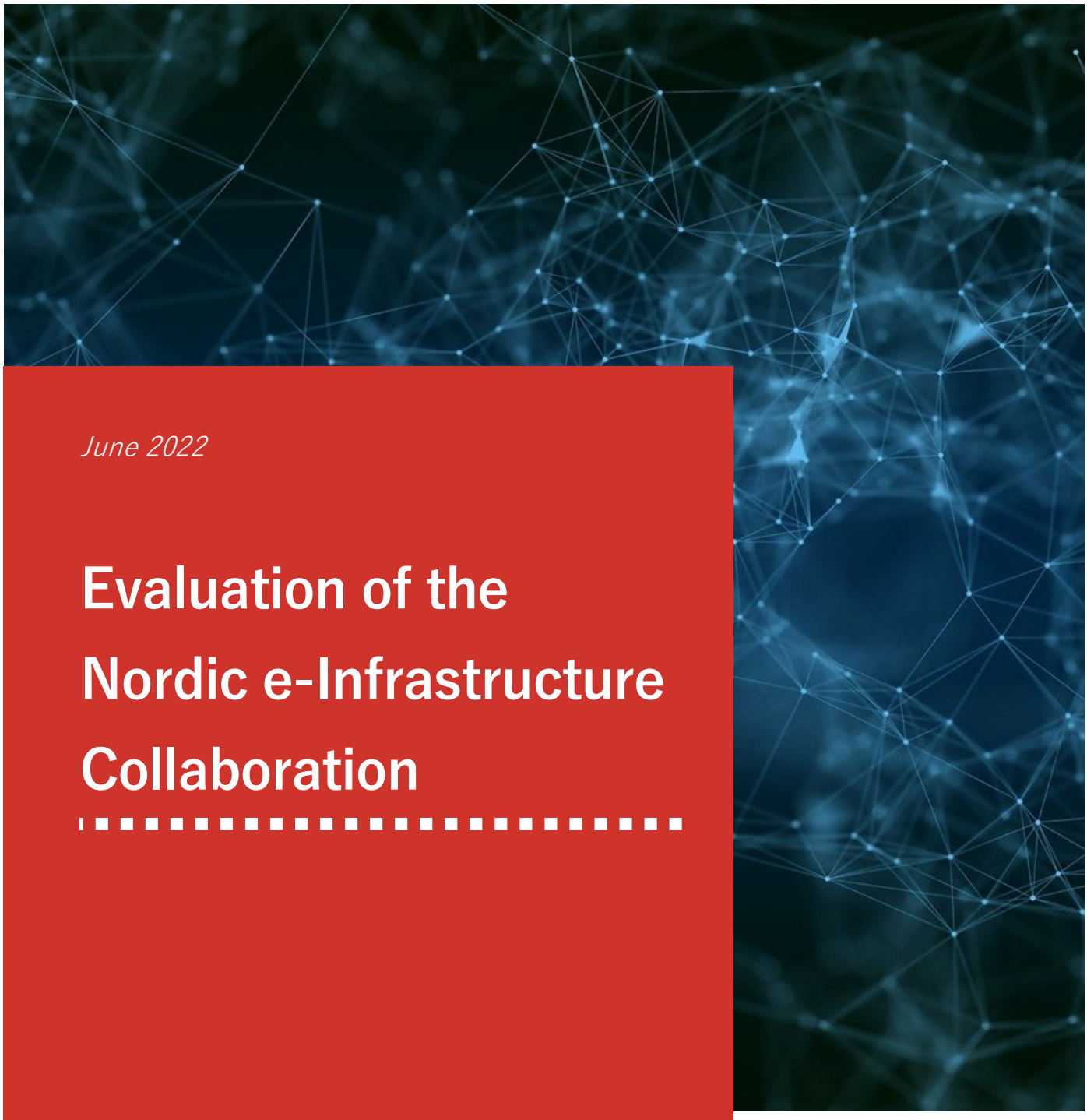

June 2022

Evaluation of the Nordic e-Infrastructure Collaboration

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Content

Summary

Technopolis Group Sweden has in collaboration with Technopolis Amsterdam and external expertise in research infrastructure conducted an evaluation of the Nordic e-infrastructure collaboration (NeIC).

The aim of the evaluation is to assess how:

- NeIC has succeeded in its tasks and created Nordic Added Value (NAV) through e-infrastructures for science and research
- NeICs benefits can be improved in terms of strategy, organisation, resources, activities, and project management
- NeICs strategy and organisation are prepared for a future development for e-infrastructure collaboration that creates NAV

Conclusions and recommendations cover both NeICs current organisational performance and impact in terms of NAV, and future development of e-infrastructure collaboration in the Nordic, so that NeIC can maintain and improve its contributions to Nordic research e-infrastructure cooperation. The evaluation covers the period 2012–2022 and includes the operations of the Nordic WLCG tier-1 facility and a selection of ongoing and past projects that explore and develop innovative infrastructure services.

The Nordic e-infrastructure collaboration (NeIC)

NeIC was established in 2012 with the key objective to stimulate development and sustainability of Nordic research e-infrastructures and to enhance the productivity of researchers in the Nordic region beyond national efforts through new services, pooling competencies and sharing the resources of national e-infrastructure providers.

NeIC's first role is to coordinate the operations of the Nordic distributed WLCG Tier-1 facility (NT-1). The second role is to explore and develop innovative infrastructure services in response to the strategic priorities in e-infrastructure and the needs of the national e-infrastructure providers within the Nordic region.

Effectiveness

NeIC has succeeded in coordinating the operations of the NT-1 facility. In NT-1, representation of user needs is adequate, and activities are aligned with the ambitions of the Nordic countries. Representation of users for developing new services is working quite well in NeIC projects. However, there is some uncertainty among key stakeholders whether the project portfolio has an

adequate representation of users and if activities have been aligned with actual existing needs by its users.

NeIC has succeeded in being a platform for Nordic e-infrastructure communities to explore, evaluate, and develop innovative infrastructure services. However, NeIC has been less effective in deploying innovative infrastructure services in response to common strategic priorities within the Nordic region. NeIC's reduced ability to adapt to changes in national objectives and strategies in e-infrastructure might affect the deployment of the services of NeIC projects at national levels negatively.

Relevance

The distributed organisational set-up of NeIC has been a good model for the collaboration (both for NeIC Board, director, and employees, and NordForsk, as well as NT-1 and projects) mainly because it helps keep the costs down and shared competences creates an added value. The distributed setup facilitates cooperation between relevant stakeholders in a sufficient manner. However, NeIC could offer more opportunities for stakeholders to exchange knowledge and experiences.

Nordic user needs are represented in the current organisation structure of NeIC and projects are in general aligned with actual existing needs by its users. However, because of developments in the Nordic Countries e-infrastructure landscape and NeIC's lack of a clear strategic mandate and difficulties to adapt, NeIC's plans, strategy, and project portfolio might not always be aligned with higher-level strategies and/or expectations of the national NeIC-stakeholders. This also affects NeIC's alignment of activities and performance in relation to the possibilities of creating NAV.

Impact

NeIC contributes to NAV as a platform for collaboration on e-infrastructure. Various project and activities under NeIC would most likely not have been conducted without the existence of NeIC and many projects are perceived as providing NAV. However, NeIC's presented results on NAV are somewhat unsystematic and anecdotal. There is a strong consensus among key stakeholders that NAV is anchored and understood regarding NT-1, but more varied regarding several of the other projects in NeIC's portfolio according. This variety is an indication that there is room for continued attention to NAV in the management of the portfolio and selection of new projects.

NeIC has to a large degree succeeded in promoting scientific excellence within the Nordic region and beyond. This is most clearly stated regarding the NT-1 activities, but with a greater variety also in relation to several other projects. For some of these projects it is too early to notice impact on scientific excellence and for some the impact is more indirect. However, NeIC needs to pay more attention to communicating its results and services and prioritize its reach outside the established NeIC-networks, to further improve and widen its impact on scientific excellence.

Sustainability

NeIC's current strategy puts an emphasis on sustaining project results and actions have been taken to further enhance the sustainability of services beyond the project lifecycle. However, even though NeIC is committed to the realisation of benefit realisation, there is still room for improvement.

The commitment in terms of funding structure for NeIC varies throughout the Nordic countries. As NeIC has grown over time and expanded its activities, its stakeholders have not kept up with the new directions of NeIC. The Nordic cooperation in e-infrastructure needs to be backed up by clear and shared commitments to NeIC regarding its strategy and activities. NeIC needs a clear strategic direction and mandate from its key stakeholders, specifically the NordForsk Board and national research infrastructure funders (NRICC committee under NordForsk) to improve NeIC's preparedness for further development. For NeIC's potential to be fully realised, these stakeholders need to have a common understanding and position on NeIC. Future investment in Nordic e-infrastructure cooperation must go hand in hand with efficient resource utilisation and well-considered strategic choices.

Recommendations

NeIC has developed well as a distributed organisation over the past decade within a rapid evolving and complex multi-layered ecosystem. NeIC has grown over time in terms of funding, projects, members, and complexity. NeIC has expanded its activities from services for high-energy physicists to sensitive data management, climate modelling, biodiversity, collaboration in high-performance computing, and harmonisation of policy and service provisioning in the Nordic and EU. NeIC operates a high-quality and sustainable Nordic Tier-1 service supporting the Large Hadron Collider (LHC) research programme.

However, NeICs strategy is quite complex with several priorities. NeIC has expanded the project portfolio in directions and at a pace that key stakeholders have not kept up with. There is a need for NeIC to be more aligned with national strategies and priorities and deepen the understanding of the development on national and EU level to be able to find a common Nordic ground due to the accelerating development pace of e-infrastructure services internationally. Organisational consolidation, strategic growth, and better integration with NordForsk and national key stakeholders is assessed to be critical focal points for the years to come, to achieve maximum NAV.

Key overall recommendations

- Set up a Nordic e-Forum for the national e-infrastructure provider organisations (NeIC Board), National research infrastructure funders (NRICC), NordForsk and NeIC team where challenges and strategies can be discussed. The Forum should be organized or co-organized by or with NordForsk to strengthen strategic coherence of NeIC and NordForsk

- In the forthcoming NordForsk strategy, set an overall strategy and a clear priority for NeIC. In this process, NordForsk Board and NRICC should have a dialogue with the NeIC Board. NordForsk Board, NRICC and the national e-infrastructure providers (through NeIC Board) needs to jointly decide on NeIC's future role and funding
- Set up a renewed MoU between the funding agencies for a new period to secure the long-term base funding of NeIC and provide a strong foundation for continued and stepwise strategic developments and secured core functionalities

Recommendations to NordForsk Board

- Continue to host and financially support NeIC, in particular NT-1 but also other projects
- Facilitate a process to identify and secure more strategy and portfolio integration and synergies between NordForsk and NeIC in close dialogue with the national stakeholders

Recommendations to NeIC Board

- Simplify forthcoming strategies and plans and reduce complexity within the organisation and portfolio.
- Develop a long-term plan to secure generational change in project management and leadership
- Pay increased attention on securing NAV in all the operations and communicating NAV to key stakeholders, both for NT1, projects and NeIC as an organisation.
- Participate only in carefully assessed and strategically selected EU-projects where there is a strong NAV.
- Pay increased attention on creating sustainability of projects results and communicate/create awareness of available services outside the NeIC network

Recommendations to NRICC (national research infrastructure funding organisations)

- Continue to financially support NeIC and work with NordForsk in developing an overall strategic framework and priorities for NeIC
- Seek to align the national funding periods in order to keep administrative burden at a low level for NeIC
- Support NeIC in communicating results and create awareness on benefits from NeIC activities and projects on the national level

1 Introduction

1.1 The assignment

Technopolis Group Sweden has in collaboration with Technopolis Amsterdam and external expertise in research infrastructure conducted an evaluation of the Nordic e-infrastructure collaboration (NeIC). The evaluation has been commissioned by NordForsk based on an open competition.

The aim of the evaluation is to assess how:

- NeIC has succeeded in its tasks and created Nordic Added Value (NAV) through e-infrastructures for science and research
- NeICs benefits can be improved in terms of strategy, organisation, resources, activities, and project management
- NeICs strategy and organisation are prepared for a future development for e-infrastructure collaboration that creates NAV

Conclusions and recommendations cover both NeICs current organisational performance and impact in terms of NAV, and future development of e-infrastructure collaboration in the Nordic, so that NeIC can maintain and improve its contributions to Nordic research e-infrastructure cooperation.

The evaluation includes assessments of

- whether the NeIC strategy, organisational structure and performance can deliver value for common strategic research domains where there exist true needs by users/researchers
- how NeIC has succeeded in coordinating the operations of the Nordic WLCG tier-1 facility (NT-1)
- how NeIC has offered a platform for Nordic e-infrastructure communities to explore, evaluate, develop, and deploy innovative infrastructure services in response to common strategic priorities within the Nordic region
- how the NeIC-strategy, organisational set-up, and performance are aligned with the expectations from its stakeholders

The evaluation covers the period 2012–2022 and includes ongoing activities (NT-1), and a selection of ongoing and past projects that explore and develop innovative infrastructure services: TRYGGVE 2, EISCAT_3D DATA SOLUTIONS, PUHURI, HEILSA TRYGGVEDOTTIR, NICEST2, EOSC-Nordic, CODEREFINARY and PARI.

The evaluation is linked to the recent evaluation of NordForsk[1] since NeIC is hosted by NordForsk and partly funded by NordForsk. The evaluation of NordForsk included recommendations, among others, of a more active portfolio steering from the NordForsk Board, and more focus on NAV as a guiding principle as well as a principle to maximise Nordic benefits of the funded projects. In addition, NordForsk was recommended to pay more attention on building systematic knowledge on impact and Nordic value added, and to raise the level of ambition in strategic communication, by communicating achieved NAV to key stakeholders. Our conclusions and recommendations in this evaluation are in alignment with the abovementioned recommendations.

1.2 Methodology and implementation

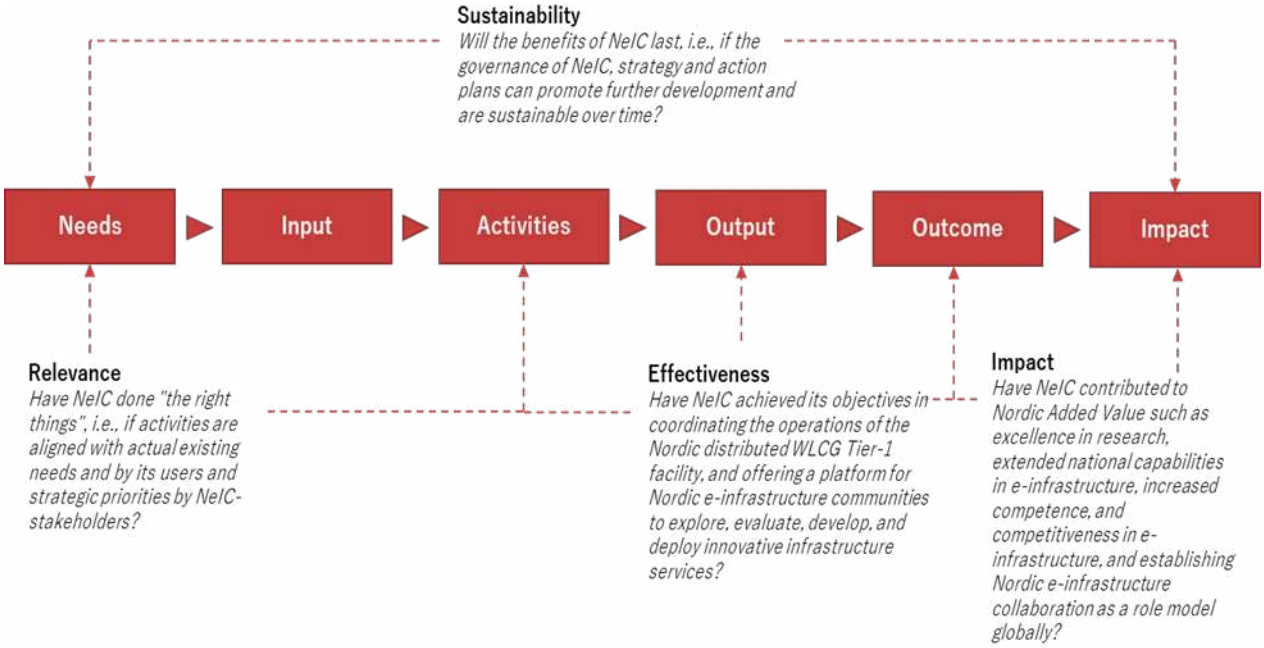
We have analysed NeIC based on the following OECD evaluation criteria: Relevance, Effectiveness, Impact and Sustainability.[2] We have applied a theory-based evaluation framework, where a theory of change illustrate how activities are intended to contribute to desired output, outcomes, and impact. This kind of evaluation framework is appropriate when the purpose is both summative and formative. The summative part of the evaluation focuses primarily on the evaluation criteria effectiveness and impact, while the formative part focuses on relevance and sustainability. When we talk about sustainability in the NeIC context we are referring to the sustainability of its services beyond the project lifecycle.

The theory of change and evaluation criteria are a useful framework for organising data collection, conducting analyses, and making assessments of NeIC. In *Figure 1*, we illustrate how the evaluation criteria relate to the theory of change.

[1] Evaluation of NordForsk. Danish Technological Institute represented by Policy and Business Development and Faugert & Co Utvärdering AB (Technopolis Group, Sweden), 2022.

[2] Applying Evaluation Criteria Thoughtfully, OECD, 2021.

Figure 1 Evaluation criteria in relation to theory of change



In *Table 1* we give an overview of how the evaluation questions relate to the evaluation criteria of the evaluation, and what kind of data collection methods that are applied in the study to address these questions.

Table 1: Evaluation criteria, questions, and methods

Criteria	Evaluation question	Data collection method	Question answered in chapter
Effectiveness	• How has NeIC succeeded in coordinating the operations of the Nordic distributed Worldwide Large Hadron Collider Computing Grid (WLCG) Tier-1 facility? How well has the coordination activities been aligned with actual existing needs by its users? Is the level of activities in line with the strategic ambitions of the Nordic countries and user needs? • How has NeIC succeeded in offering a platform for Nordic e-infrastructure communities to explore, evaluate, develop, and deploy innovative infrastructure services in response to common strategic priorities within the Nordic region?	• Desk Review • Self-assessment • Survey • Interviews	• Chapter 3
Impact[3]	• How has NeIC contributed to create NAV and impact in its different activities?	• Desk Review	• Chapter 5

[3] Nordic Added Value for NeIC Collaborations
https://wiki.neic.no/w/ext/img_auth.php/0/04/Nordic_Added_Value_for_NeIC_collaborations.pdf

	– i. How well has NeIC succeeded in promoting excellence in research? – ii. How well has NeIC succeeded in adding value to the Nordics beyond national capabilities in e-infrastructure? – iii. How well has NeIC succeeded in increasing competence and competitiveness in e-infrastructure? – iv. How well has NeIC succeeded in acting as a global role model for e-infrastructure collaborations by creating the profile of a knowledge-based region? – v. Which part of NeIC's portfolio of activities has been most fruitful in terms of results and impact, including societal added value and impact beyond academia? – vi. Has NeIC contributed to the national higher-level infrastructure strategies in the Nordic region? If yes, how? – vii. Has NeIC contributed as a facilitator of open access and Open Science? If yes, how? – viii. How well has NeIC contributed to the Nordic eScience action plan(s)?	• Self-assessment • Survey • Interviews	
Relevance	• Has the distributed organisational set-up of NeIC been a good model for the collaboration – for the NeIC Board, director and employees, and NordForsk? – to handle services and promote sustainable support through NT-1? – for other NeIC activities including project management? • How well are Nordic users and their needs for developing services represented in the current organisation structure of NeIC? • How well are the NeIC strategy, plans for activities and performance aligned with the expectations for creation of NAV and other higher-level strategies of the NeIC-stakeholders?	• Desk Review • Self-assessment • Survey • Interviews	Chapter 4
Sustainability	• Do the strategy and plans for activities promote a further development of the collaboration, both in terms of maintaining ongoing activities as well as inclusion of new activities? • How well is the NeIC organisation prepared for a future development for e-infrastructure cooperation, including maintaining the on-going collaboration as well as inclusion of future infrastructure cooperation activities?	• Desk Review • Self-assessment • Interviews	• Chapter 6
Lessons and recommendations	• What adjustments of the NeIC strategy, organisation, activities, and project management, should be implemented to improve the created value for common Nordic strategic research	• All methods	• Chapter 7

	domains where there exist true needs by users/researchers? • Is there a need to adjust in terms of level of resources?		

Our methodology involved desk studies, a self-assessment, interviews with stakeholders, and a survey to assess the performance, activities, organisation, and NAV. Our methodology used predominantly qualitative methods since the evaluation questions are of a qualitative character. In *Table 2*, we present the methodological approach for evaluating NeIC.[4]

Table 2: Methodological approach

Activity	Purpose	Approach and Data Sources
1. **Desk Review**	To map the rationale of NeIC	• Review of key reports, impact assessment, international policy/academic literature
2. **Self-assessment**	To identify questions for data collection in the evaluation, including performance indicators	• Self-assessment report by NeIC, including assessment of performance and achievement of strategy and mandate, and statistical data on performance.
3. **Interviews**	Data collection informed by the Desk review and self-assessment	• 22 in-depth semi-structured interviews with key stakeholders that are directly or indirectly involved in or benefit from Nordic e-infrastructure: – The national e-infrastructure provider organisations (NeIC Board) – NeIC team – National research infrastructure funders (Nordic Research Infrastructure Collaboration Committee, (NRICC) advisory role to NordForsk Board) – National funding agencies (Chair of NordForsk Board) – NordForsk administration (Director) – Nordic Council of Ministers (Secretariat) – NeIC-activities (NT-1) and ongoing and past projects (Project leaders)
4. **Survey**	Data collection informed by the Desk review and self-assessment	• A NeIC-activity (NT-1) survey (with NT-1 steering group and NLCG committee) • A NeIC-projects survey (with project steering groups and project reference groups), including all ongoing projects and a selection of past NeIC-projects The surveys allowed for a larger number of stakeholders, including team members and researchers represented in the project reference groups, to express their views. The survey questions were of a relatively qualitative kind,

[4] B. Sandberg & S. Faugert "Perspektiv på Utvärdering", Studentlitteratur, 2020

		thus meeting the evaluation questions, but the survey format also allowed for a quantitative summary. The survey sent to NeIC-activities stakeholders (NT-1) had a response rate of 75 percent, while the NeIC-projects survey had a response rate of 45 percent. In total, the surveys were sent to 256 contacts with a response rate of 48 percent. In the NT-1 survey, the 15 respondents were from the following types of organisations: Research infrastructure (7%), other research institute (13%), national e-infrastructure provider (33%) and university (47%). In the NeIC-project survey, the 107 respondents were from the following types of organisations: Other research institute (8%), other type of organisation (11%), research infrastructure (15%), university (21%), national e-infrastructure provider (44%).
5. **Analysis**	In relation to the evaluation questions/main scope of the evaluation	• Structured data-analysis applying Atlas.ti for qualitative data
6. **Synthesis and reporting**	Conclusions and recommendations	• To what extent NeIC has reached its goals, its organisational performance, and NAV, and what further actions are needed (recommendations)

1.3 Structure of the report

The next Chapter of this report presents NeIC in terms of governance, goals, strategy, and portfolio (activities/projects). We also give a brief overview on e-infrastructure development in in the Nordic countries and EU.

Chapter 3 focuses on the effectiveness of NeIC – if NeIC has achieved its objectives in coordinating the operations of NT-1 and offering a platform for Nordic e-infrastructure communities to explore, evaluate, develop, and deploy innovative infrastructure services.

Chapter 4 focuses on the relevance of NeIC – whether activities are aligned with actual existing needs by its users and strategic priorities by NeIC-stakeholders.

Chapter 5 discusses the impact of NeIC. In this chapter we discuss if and how NeIC has contributed to NAV such as excellence in research, extended national capabilities in e-infrastructure, increased competence, and competitiveness in e-infrastructure, and establishing Nordic e-infrastructure collaboration as a role model globally.

Chapter 6 focuses on sustainability – i. e. whether the benefits of NeIC will last, and if the governance of NeIC, strategy and action plans can promote further development and are sustainable over time.

The last Chapter provide conclusions and recommendations.

2 Nordic e-Infrastructure Collaboration

2.1 Governance

NeIC was established in 2012 with the key objective to stimulate development and sustainability of Nordic research e-infrastructures and to enhance the productivity of researchers in the Nordic region beyond national efforts through new services, pooling competencies and sharing the resources of national e-infrastructure providers. An important factor for the establishment of NeIC was the task to coordinate the operations of the Nordic distributed Worldwide Large Hadron Collider Computing Grid (WLCG) Tier-1 facility (NT-1), which provides computing and storage for CERN (Conseil Européen pour la Recherche Nucléaire) to be used by high energy physicists worldwide.

NeIC's first role is to coordinate the operations of the Nordic distributed WLCG Tier-1 facility (NT-1). The second role is to explore and develop innovative infrastructure services in response to the strategic priorities in e-infrastructure and the needs of the national e-infrastructure providers within the Nordic region.

The principal partners of NeIC are the national e-infrastructure provider organisations in the Nordic countries, NordForsk and Estonia, which formally joined the collaboration in 2020. The national e-infrastructure provider organisations are:

- DeiC (Danish e-infrastructure Cooperation) from Denmark
- CSC (CSC - IT Center for Science) from Finland
- RHnet (Icelandic University Research Network) from Iceland
- Sigma2 (Norwegian e-infrastructure for Research & Education) from Norway
- SNIC (Swedish National Infrastructure for Computing) from Sweden.
- ETAIS (Estonian Scientific Computing Infrastructure) from Estonia

NeIC was from the start a distributed organisation and hosted by NordForsk, a Nordic institution under the Nordic Council of Ministers, which facilitates cooperation on research and research infrastructure in the Nordic Region. The NeIC Board is appointed by NordForsk based on the nominations by the national e-infrastructure provider organisations. The NeIC Board consists of one representative from each of the six national e-infrastructure partners. Previously the national research funders also had one representative each in the NeIC Board. The NordForsk Board has delegated to the NeIC Board to make decisions regarding computing and data storage infrastructure, including budget, implementing the organisational structure, as well as prioritising and coordinating Nordic collaboration projects. The NeIC Board is also responsible for the NeIC strategy and for making the final decision on the funding of development projects.

NeIC's director and administrative coordinator are employed by and located at NordForsk's offices in Oslo. They are core members of NeIC's executive team. NeIC's other staff members – 70 as of December 2021 - are distributed in the Nordic region. In addition, there are 244 staff members in the EOSC-Nordic project.[5] Project personnel and project managers are contracted to work with NeIC through a service level agreement between NordForsk and the personnel's home institution. Thus, the personnel are not directly employed by NeIC.

The users of NeIC in a broad sense are the national e-infrastructure providers and research organisations that participate in NeIC's projects, the LHC researchers that participate in ALICE or ATLAS experiments (NT-1), researchers that participate in use cases or pilots of NeIC projects, and participants in the training organised by NeIC.[6]

[5] NeIC Annual report 2021

[6] NeIC Self-assessment 2022

NT-1

The Nordic Tier-1 (NT-1) facility was established in 2006 and has been an activity of NeIC since 2012. NeIC has an operational responsibility for NT-1 and its infrastructure is expected to run until at least 2038. NT-1 is one of 14 regional computing centres of the worldwide LHC computing grid (WLCG), that provide computing and storage for CERN. The main objective of NT-1 is to deliver continuously sufficient production resources to the WLCG until the agreed end, which according to the WLCG MoU, is the LHC lifetime plus 15 years. By contributing its share to the WLCG resources, the NT-1 facility enables High Energy Physics research for the scientists in the Nordics. The facility is also unique due to it being distributed across four countries: Sweden, Denmark, Finland and Norway.

The NT-1 facility is also highly relevant for NeIC's strategy as it contributes by enabling software development and ensuring that Nordic researchers have access to the resources they need. Furthermore, NT-1 directly supports more than 150 researchers in the Nordics and contributes to the Nordic Council of Ministers long-term visions, e.g. by examine ways to power the supercomputers with renewable energy. In 2021, the total NeIC budget for the NT-1-facility was approximately NOK 11 million. Out of these 67 percent were personnel costs, 30 percent were WLCG NORDUnet costs and 3 percent were travel and meeting related costs.

The personnel at NT-1 consists of 11 people from 7 partner organisations: HPC2N, UiB, UiO, CSC, NSC, LU and NBI. To make its budget more cost-effective there have been investigations on how centralizing the NT-1 operation would affect its costs. While a centralized operation is estimated to reduce costs - mainly personnel needs, network costs and infrastructure costs – with approximately € 2,3 million per year this matches the in-kind contributions from the HPC sites. Thus, the benefits of the current model were seen to be greater, and the current model was therefore kept.

Some of the main activities and services conducted at NT-1 are ALICE, ATLAS and DCACHE. ALICE is an experiment conducted at the LHC and is mainly related to the studies of quark-gluon plasma in heavy ion collisions. ATLAS is the main LHC experiment conducted at Tier-1 centres such as NT-1 and regards the search of new particles and phenomena in proton-proton collisions. Three Nordic countries, Denmark, Norway and Sweden, host ATLAS computing and storage. DCACHE is a service developed with contribution from NeIC. It organises data stored on disks and tapes in Scandinavia and accepts data from CERN and other Tier-1 facilities. "In the current model, the Nordic Tier 1 centre benefits from being part of a larger-scale high-performance computing centre at Nordic research institutions".

Several indicators can be used to measure the results of NT-1. One such indicator is the number of publications that benefited from NT-1 and its support for LHC experiments ATLAS and ALICE. Between 2011-2017, the three-year average of the number of publications that benefited from NT-1 increased with about 33 percent. One future challenge for NT-1 is the High Luminosity LHC (HL-LHC), which is an upgrade of the current LHC. This upgrade will increase the data volumes by a factor of more than 10, which presents a challenge for the NT-1 computing infrastructure and the open-source software needed for operating NT-1, regarding both funding and technology.

2.2 Goals and strategy

2.2.1 Goals

The vision for NeIC is to be a global role model for cross-border distributed and sustainable e-infrastructure collaborations. NeIC activities centre on digital infrastructure for Nordic research

excellence. Furthermore, NeIC's mission is to enable excellent academic research in the Nordic Region.[7]

The core values of NeIC are:

- NeIC services and development are motivated by providing added value to Nordic research
- NeIC shares knowledge and develops competence on advanced e-infrastructure solutions
- NeIC works in open and transparent ways to be a trustworthy partner
- NeIC strives to improve continuously in what we do

2.2.2 Strategy

Pooling competences, sharing resources, and connecting people for more effective use of research e-infrastructure is the ambition of NeIC in partnership with the national e-infrastructure providers.

To reach its overarching vision and goals, NeIC has formulated an organisational strategy. The current strategy[8] (2020 to 2025) has four strategic objectives:

1. Beneficial collaborations are the principal way that NeIC brings together the needs, interests and resources to create e-infrastructure to support research excellence in the Nordic region.
2. Nordic influence is the effect that NeIC has in improving and advancing e-infrastructure for researchers and for society.
3. Motivated people are essential in the collaborations and to bring the results into the research domains and society.
4. Effective processes bind NeIC into an organisation that is able to realise the benefits and influences that come from collaborations.

Related to the strategy there are three ranked priorities:

1. Deep Nordic interactions and collaborations
2. Society, Ethics and Sustainability for research and societal value and sustainability through e-infrastructure collaborations
3. Wide international interactions, collaborations, and new roles.

[7] NeIC Self-assessment 2022

[8] https://wiki.neic.no/wiki/NeIC_Community_Wiki#Strategy

2.2.3 *Nordic Added Value*[9]

NeIC has developed a description of NAV as it relates to NeIC and the stakeholders in NeIC's projects and included an explanation for choosing the elements derived from a search of relevant literature on added value, including beyond the Nordic region (see *Table 3*).

Table 3 The major elements of Nordic Added Value for NeIC activities

1. **Enable excellence in research**	• Increase the **competitiveness of Nordic researchers** in EU research activities or other **international research cooperation** • Increase the ability of the region to **attract talent and investments**, and enhance its appeal as a **partner in cooperation**
2. **Add value to the Nordics beyond national capabilities in e-infrastructure**	• Enhance sustainability and integration by sharing infrastructure or data or harmonising systems for utilising data and other resources in the Nordic region • Develop platforms for international cooperation
3. **Increase competence and competitiveness in e-infrastructure**	• Help to build critical mass and/or expertise at the Nordic level in important disciplines or research areas • Lead to networking among the Nordic countries
4. **Act as a global role model for e-infrastructure collaborations**	• Create the profile of a knowledge-based region • Create a model for Europe in transnational research co-operation

2.2.4 *Society, Ethics and Sustainability*

The NeIC Board has decided to put emphasis on Society, Ethics and Sustainability as a mechanism to define and clarify NeICs role, especially in the Nordic region, for the strategic period 2020-2025 (see *Table 4*).[10]

Table 4: The main actions taken by NeIC to ensure Societal, Sustainable and Ethical benefits

Society	• Using impacts analysis as a mechanism to describe and review how NeIC benefits society through the work of NeIC projects, training activities and benefit realisation management • Communicating NeIC benefits on society, e.g. in the NeIC Annual Report and in NeIC news articles
Sustainability	• Using impacts analysis as a mechanism to describe and review NeIC contribution to a sustainable globe by mapping projects to the UN SDGs (Sustainable Development Goals) and the Nordic Council of Ministers vision

[9] Nordic Added Value for NeIC Collaborations https://wiki.neic.no/w/ext/img_auth.php/0/04/Nordic_Added_Value_for_NeIC_collaborations.pdf

[10] Policy on Society, Ethics and Sustainability. https://wiki.neic.no/wiki/Policy_on_Society,_Ethics_and_Sustainability

	• Communicating NeIC's contribution to the UN SDGs and the NCM vision, e.g., in the NeIC Annual Report and in NeIC news articles
Ethics	• Any concerns on ethical matters within a NeIC project are to be raised to the Project Owner and discussed together with all Project Managers or the NeIC Executive Team (XT). General questions regarding ethical matters are to be raised to XT. • Relevant NeIC policies and the Core Values are to be reviewed on a regular basis.

2.3 Budget

NeIC's budget has grown considerably since 2012 and is today almost four times as large.[11] Current funding for NeIC activities and projects is provided through national research funding agencies, NordForsk and participating project partners.

In 2021, national research funding agencies contributions were NOK 15.5 million, NordForsk co-funding NOK 20 million and partner co-funding of NOK 21.1 million (in-kind funding from national e-infrastructure provider organisations and university partners).[12]

NordForsk's funding in 2021 was one fourth of the total NeIC funding, meaning every NOK NordForsk invests in NeIC results in four NOK of Nordic e-infrastructure collaboration. One of the three NOK of matching funding is external European funding. This is due to NeIC's coordination of the by EC funded EOSC-Nordic project"t to the coordination of e-infrastructure projects in the Nordic Region funded by the European Commission, the EOSC-Nordic project.

The Nordic funding arrangements for NeIC set up back in 2012 – The Memorandum of Understanding between five national research funding agencies and NordForsk – will end in December 2022.[13]

[11] NeIC Self-assessment 2022

[12] NeIC Annual report 2021

[13] https://wiki.neic.no/w/ext/img_auth.php/4/49/130506-NeIC-MoU-signed-by-all.pdf

EOSC-Nordic

EOSC-Nordic is an ongoing project funded by the EU framework programme Horizon 2020 with a total budget of NOK 61.4 million. The project started 1 September 2019 and is expected to end on 30 November 2022. In total, the project consists of 24 partners from Norway, Sweden, Finland, Denmark, Iceland, Estonia, Latvia, Lithuania, Germany, and the Netherlands.

The European Open Science Cloud (EOSC) is an initiative by the European Commission aiming at developing an infrastructure providing its users with services promoting Open Science practices in Europe. The overall aim of EOSC-Nordic is to establish the Nordic and Baltic countries as frontrunners in the implementation of the EOSC concept, principles, and approach.

The projects objectives are to: 1. facilitate the alignment of the delivery of horizontal services by improving interoperability practices across the national initiatives, 2. identify and engage with prospective service providers and support their integration with the EOSC catalogue, service management framework and operational environment, 3. facilitate close collaborations on data management to promote best practices and support the adoption of relevant certification schemes, 4. demonstrate the potential of EOSC by piloting innovative solutions, designed to support cross border research collaboration, using the Nordic and Baltic countries as a testbed environment and 5. consolidate and expand a distributed network of experts and service operators at local and national levels.

Some activities conducted within EOSC-Nordic includes support for research on COVID-19 and the creation of an EOSC-Nordic knowledge hub in which all resources and information relevant to EOSC-Nordic can be found. To measure the effects of the project 11 Key Performance Indicators (KPI) are being used. Some of these KPIs are the number of published services in the EOSC Portal, the number of stakeholders consulted by the project studies and activities and the amount of computing facilities accessible through community specific portals. EOSC-Nordic have continuously shown positive results in relation to these KPIs throughout the projects duration.

2.4 Project portfolio

NeIC's project portfolio consists of activities, active projects and projects in preparation, and active pre-studies. Since 2012, NeIC has grown in terms of the volume of its projects. At first NeIC had 12 partners in the Nordic countries and the main activity was NT-1. In 2021, NeIC's portfolio included NT-1 and eight development projects with 49 partner institutions in 11 countries.[14]

NT-1 operates a Nordic Tier-1 service supporting the Large Hadron Collider (LHC) research programme. The main objective of NT-1 is to deliver continuously sufficient production resources towards the Worldwide LHC (WLHC) Computing Grid. Except for the NT-1 facility activity, the main ongoing projects are:

- PUHURI – aimed at facilitating seamless access to the LUMI supercomputer, one of the EuroHPC supercomputers which will be located in Finland, and deploying services for resource allocation and tracking, as well as federated group management[15]

[14] NeIC Self-assessment 2022

[15] https://neic.no/puhuri/

- HEILSA TRYGGVEDOTTIR – project co-funded by NeIC and the ELIXIR nodes in Denmark, Estonia, Finland, Norway and Sweden and aimed at utilising existing technologies and expertise related to sensitive data in the Nordic countries and by working in close collaboration with Nordic user communities[16]
- NICEST2 – focused on strengthening the Nordic position within climate modelling by leveraging, reinforcing, and complementing ongoing initiatives[17]
- CODEREFINARY – provides researchers with infrastructure and training in the tools and techniques necessary to create sustainable, modular, reusable, and reproducible software[18]
- EOSC-Nordic – coordinated by NeIC and based on EU funding, facilitates the coordination of initiatives relevant to the European Open Science Cloud (EOSC) within the Nordic and Baltic countries[19]

NeIC has a process for initiating new projects: the open calls for development projects. NeIC's open calls invite consortia consisting of e-infrastructure providers, developers, researchers, and related communities to propose e-infrastructure collaboration projects of joint Nordic interest. In addition, NeIC invites consortia to submit proposals for community-forming pre-studies. A pre-study is a shorter-term collaboration model than the development project to explore synergies of e-infrastructure solutions and to scope out a future development project.

The 2021 open call, resulted in the launch of three projects in 2022: a third phase of CodeRefinery, a second phase of PUHURI, and NordIQuEst – a new project focusing on establishing e-infrastructure for quantum computing.

A common theme in NT-1 and all the projects mentioned above is that they centre around strengthening e-infrastructure in the Nordics, by giving access to e-infrastructure and scientific computing. Furthermore, they all aim to do this by deep cross-border collaborations, mainly with national e-infrastructure providers in the Nordics, but also with other European organisations as is the case with the EOSC-Nordic project.

While the projects and activities all centre around strengthening e-infrastructure in some form, the areas in which they aim to strengthen it in differ. NeIC projects are involved in a wide range of sciences, such as physics and engineering sciences, environmental sciences, life sciences? and e-sciences.

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[16] https://neic.no/heilsa/

[17] https://neic.no/nicest2/

[18] https://neic.no/coderefinery/

[19] https://neic.no/eosc-nordic/

In current and past projects, two of the main themes except e-infrastructure were health (TRYGGVE, TRYGGVE2, HEILSA TRYGGVEDOTTIR, PARI and EOSC-Nordic) and climate (NICEST2 and EOSC-Nordic). Some projects such as EOSC-Nordic are not specifically focusing on one theme, but a wide variety, and instead tend to focus on strengthening collaborations as one of its main objectives. PUHURI is an example of a project on general e-infrastructure services initiated by the national e-infrastructure providers to enable cross-border service access for Nordic scientists. Its focus is enabling Nordic access to the HPC system resources of LUMI.

PUHURI

PUHURI is an ongoing project that started 1 June 2020 and is expected to end in 2022. The total budget of the project is NOK 6 million in which NeIC contributes with 52 percent. The idea behind it is that implementing an AAI (authorization and authentication infrastructure) and resource allocation federated services will result in reduced administration costs and better usability.

PUHURI has two main objectives: firstly, to develop seamless access to the LUMI supercomputer and secondly, to deploy services for resource allocation, tracking, and federated group management. With seamless access to LUMI Services researchers could gain access through their university instead of a specific password. The consortium includes CSC, University of Iceland, Sigma2, ETAIS, SNIC and DeiC. PUHURI technology will also be available in other NeIC projects such as EOSC-Nordic in which its knowledge hub could use PUHURI AAI Services.

To achieve its objectives, four main activities were outlined in the project plan. Firstly, to integrate LUMI services to PUHURI, secondly, resource management, accounting and reporting services, thirdly, making sure that the other activities within the project can be integrated with the national portals and fourthly, implementing an AAI collaboration. Regarding long-term sustainability, the total net benefit of PUHURI is estimated to be about 69 FTEs. Other countries than those with partner organisations involved have also shown an interest in the project. Two such countries are Croatia and Slovenia, which indicates a potential outreach further than the Nordics.

In addition, NeIC has complemented and extended national e-infrastructures and, through Nordic collaboration, provided a platform for development of common agendas toward European initiatives of interest. NeIC has expanded its activities in relation to major EU initiatives such as the EOSC-Nordic project and the European High-Performance Computing Joint Undertaking (EuroHPC JU), through the project PUHURI.

2.5 E-infrastructure developments in the Nordic countries and EU

Research is becoming increasingly international, and e-infrastructures is no exception. The international level in e-infrastructure has grown significantly in recent years. Well-functioning research e-infrastructures are vital for the continued development of Nordic research and society. Development of international e-infrastructures foster the emergence of new working methods in research based on shared use of ICT tools and resources across different disciplines and technology domains as well as sharing of results and an open way of working together.

The policy environment of NeIC is changing, both on national and European level. Extensive work is underway nationally with the aim of providing research in the Nordic countries with the e-

infrastructure support required. Funding in this area is also increasing. But several of the Nordic countries have challenges, dealing with a fragmented landscape with many actors and a lack of coordination. This complicates e-infrastructure strategies for research on national level. This problem concerns to a large extent Sweden but also to other Nordic countries, including Norway and Denmark.[20]

Finland is the country that has come the furthest in establishing a cohesive organisation. The CSC is a comprehensive organisation with a broad mission to support research, the university and college sector and other parts of the public sector. Denmark is in the process of establishing a cohesive organisation for e-infrastructure. In 2019, the universities and the Ministry of Education and Research published a Strategy for national collaboration on digital research infrastructure.[21] DeiC has so far been a legal entity under the Ministry of Education and Research with all employees employed at DTU. It is the intention that DeiC will be established as an independent institution at the beginning of 2022. Sweden is possibly also in the process of establishing a cohesive organisation for e-infrastructure.[22] In Norway, development is taking place around their computer resources coordinated within Sigma2.

E-infrastructure is on the agenda in many countries as an effect of the increased technical possibilities, and increasingly complex data sets, the requirements of research, the requirements for open and FAIR (Findability, Accessibility, Interoperability, and Reuse) research data and issues about personal integrity.[23] The complexity is also driven by the rapid development within the EU, for example the EOSC, the EuroHPC JU (of which LUMI is part and all Nordic countries are members) and Gaia-X (a decentralised federated and secure European data infrastructure in development). EOSC work for Open Science and also strives to coordinate and make available digital resources and research services, in particular computational resources, and storage capacity. In terms of calculation resources, there is a direct link to the EuroHPC initiative.

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[20] Inriktningsförslag för organisering av svensk e-infrastruktur för forskning, Vetenskapsrådet 2020

[21] https://ufm.dk/publikationer/2019/strategi-for-nationalt-samarbejde-om-digital-forskningsinfrastruktur

[22] SOU 2021:65, Stärkt fokus på framtidens forskningsinfrastruktur. Slutbetänkande av Utredningen om organisation, styrning och finansiering av forskningsinfrastruktur. Stockholm 2021.

[23] Wilkinson MD, Dumontier M, Aalbersberg IJ, Appleton G, Axton M, Baak A, Blomberg N, Boiten JW, da Silva Santos LB, Bourne PE, Bouwman J, Brookes AJ, Clark T, Crosas M, Dillo I, Dumon O, Edmunds S, Evelo CT, Finkers R, Gonzalez-Beltran A, Gray AJ, Groth P, Goble C, Grethe JS, Heringa J, 't Hoen PA, Hooft R, Kuhn T, Kok R, Kok J, Lusher SJ, Martone ME, Mons A, Packer AL, Persson B, Rocca-Serra P, Roos M, van Schaik R, Sansone SA, Schultes E, Sengstag T, Slater T, Strawn G, Swertz MA, Thompson M, van der Lei J, van Mulligen E, Velterop J, Waagmeester A, Wittenburg P, Wolstencroft K, Zhao J, Mons B. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data. 2016 Mar 15;3:160018. doi: 10.1038/sdata.2016.18. Erratum in: Sci Data. 2019 Mar 19;6(1):6. PMID: 26978244; PMCID: PMC4792175.

The developments at European level are driven by the European Commission's Digital Europe Programme that was launched last year. The programme[24] aims to support the digital transition in the EU by fostering the uptake of digital technologies and enhancing digital skills. E-infrastructure have a central place within this programme within the special objective on High Performance Computing (HPC). The actions under this initiative are managed by the EuroHPC JU. Within this objective, the EC aims to reach post-exascale supercomputing capabilities within 7 years' time and to widen the use of supercomputing to other (scientific) domains and across society. Investments are made in infrastructure, but also in cross-border interconnecting of infrastructures, data spaces and cloud ecosystems. Actions include (amongst others) the federation of HPC resources and services, the establishment of thematic data spaces (for example a Federated European Infrastructure for Genomics data and for Cancer Images data), developing education programmes on advanced digital skills and developing quantum communication infrastructure. These actions relate to the various projects that are being conducted by NeIC and at national level.[25]

Many activities on European level are aimed at collaboration between e-infrastructures (in particular HPC centres) in Member States. NeIC is an example of such a collaboration and as such could fit well in the efforts and ambitions within EuroHPC. Synergies between needs and competences usually drive such collaborations, in combination with the possibility to acquire funding for collaborative activities that benefit their users.

Most e-infrastructures in Europe traditionally emerged from science and are still primarily a research infrastructure. Initially their focus has often been on the natural sciences, especially astronomy, physics and meteorology in which large data sets and complex computational models and calculation had to be run. In recent years, various developments have impacted the focus, roles, tasks and activities of e-infrastructures in Europe[26]:

- The wider adoption of AI, machine learning and data science methods in research has increased the number and variety of scientific domains that wish to use e-infrastructures. This results in new/wider demands and requirements regarding services, software and infrastructure.
- Developments in Open Science have extended the roles and requirement of some e-infrastructures. The storage of a wider variety of scientific data, not just large data sets for

[24] European Commission (2022). The Digital Europe Programme. https://digital-strategy.ec.europa.eu/en/activities/digital-programme.

[25] European Commission (2021). Digital Europe Work Programme 2021-2022.

[26] Based on a study and benchmark performed by Technopolis Group in 2021 for the Flemish Supercomputer Centre.

calculations or from large-scale experiments, using FAIR principles have been added to the role of various e-infrastructures.

- Widening of the user base and services from purely aimed at research institutes and academia to also supporting science-based business, start-ups and Research & Development projects in industry. Usually this still concerns a small amount of the total usage, but it provides a way to valorise the activities of e-infrastructure and strengthen their impact on economy and society, while also generating a new source of revenues and a base for collaboration between science and business. It also aligns with the aims of the Digital Europe Programme regarding the uptake of HPC by society, such as propelled by the European Digital Innovation Hubs.[27]

Such trends or developments could provide a fruitful base for collaboration in the Nordics, as knowledge and investments can be shared and approaches can be aligned. This is usually more efficient. NeIC has taken this role regarding Open Science with the EOSC-Nordic project, and also in novel developments regarding LUMI and quantum computing.

[27] European Commission (2021). Digital Europe Work Programme 2021-2022.

3 Effectiveness

This chapter addresses if NeIC has achieved its objectives in coordinating the operations of the NT-1, if representation of user needs is adequate, if level of activities are in line with the ambitions of the Nordic countries, and if NeIC is offering a platform for Nordic e-infrastructure communities to explore, evaluate, develop, and deploy innovative infrastructure services in response to common strategic priorities within the Nordic region.

3.1 Coordination and representation of user needs

NeIC provides the governance structure, interacts with Nordic user representatives, coordinates six computing sites in the Nordic region and manages the central operations and middleware deployment for the NT-1 facility. NT-1 has a steering group and the Nordic LHC Computing Grid (NLCG) committee, which is a reference group that is governed by terms of reference and approved by NeIC's board. The NLCG committee consists of two members from each country, representing CERN experiments and national infrastructure providers.

According to NeIC's self-assessment, the computing and storage resources offered through NT-1, are accessible for all scientists working with Large Hadron Collider experiments. Members of ALICE and ATLAS experiments (worldwide) use the NT-1 facility, with an annual number of authors (users) of approximately 7 000. NeIC's self-assessment points out that "by combining the independent national contributions through a synchronised operation of NT-1 by NeIC, the total Nordic contribution reaches a critical mass with higher impact, resilience, and risk mitigation, saves costs, pools skills, and enables a more beneficial scientific return by better serving large-scale storage and computing needs."[28]

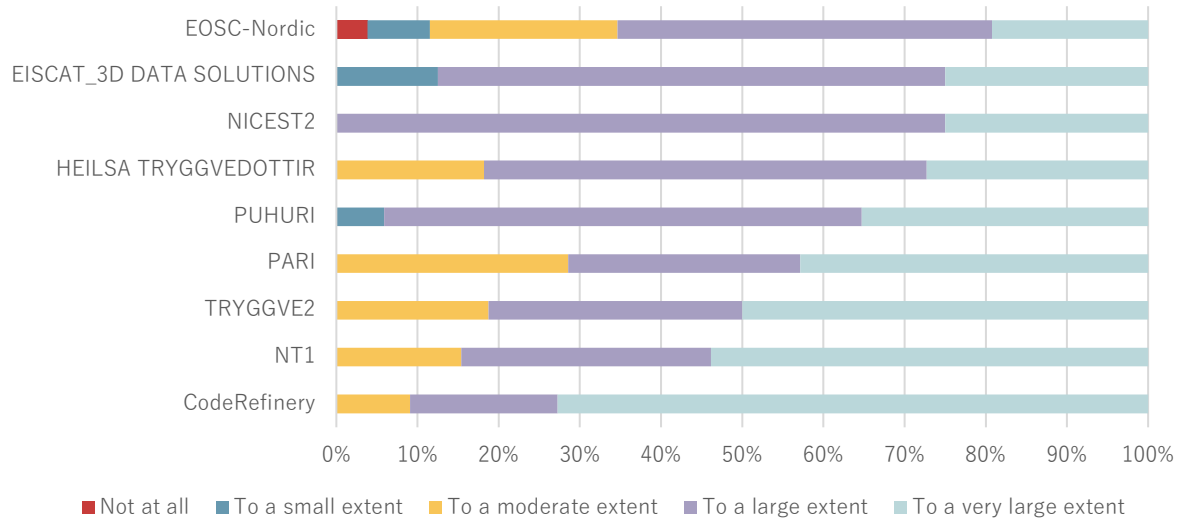
Interviews with key stakeholders, such as the NeIC Board, NRICC and NT-1 project leader, indicates that NeIC has succeeded in coordinating the operations of NT-1. The interviewees generally confirms that the coordinated activities have included representations of Nordic user needs. The level of activities NT-1 is in line with the strategic ambitions of the Nordic countries. However, a few interviewees point out that there might be a need to discuss the strategic ambitions of the Nordic countries for NT-1 in the future, and further develop the cooperation model of NT-1, since the infrastructure offered through NT-1 is expected to be crucial for high energy physics researchers in the Nordic until 2038. This issue is also addressed in the internal evaluation of NT-1.[29]

[28] NeIC Self-assessment 2022

[29] Nordic WLCG Tier-1(NT1) facility evaluation

Survey data support the self-assessment and interviews on NT-1, indicating that respondents consider Nordic user needs to be represented to a large extent in NT-1, as illustrated in *Figure 2.* In the NT-1 survey, the 15 respondents were from the the following types of organisations: Research infrastructure (7%), other research institute (13%), national e-infrastructure provider (33%) and university (47%).

Figure 2 Are Nordic users' needs for developing services represented in the projects?



Nordic users are represented in the current organisation structure through the NeIC projects. All projects have steering groups with representatives from the consortium partners. The steering group's responsibility is to make sure that the project addresses its stated goals are of value for the partners, users, and other national stakeholders in the Nordic region. In addition, the project reference groups are contributing to stakeholder involvement as they are comprised of representatives from user communities, e-infrastructure operations, and other experts. The reference group provides feedback on the project's deliverables, thereby linking project goals, activities and the needs of the researchers and communities who will make use of the project outcomes. As mentioned, the project leaders confirm that the steering and reference groups are successful in making sure that the projects are aligned with actual existing needs by its users.

The survey data indicates that the respondents generally considers that user needs are well represented in NeIC projects. In the NeIC-project survey, the 107 respondents represented the following types of organisations: Other research institute (8%), other type of organisation (11%), research infrastructure (15%), university (21%), national e-infrastructure provider (44%). Over 80 percent of respondents answered that Nordic users' needs were represented to a large or very large extent. Furthermore, interviews with project managers confirms the survey data findings on projects. However, interviews indicate that the research councils (NRICC) and NordForsk seem to

have limited insight to NeIC, hence creating a situation where representation of user needs in the project portfolio is less visible (and tangible) from their perspective.

Survey results are most positive for the projects NICEST 2, CodeRefinary and PUHURI. For EOSC-Nordic, on the other hand, respondents stated that the project considered Nordic user needs to a lesser extent, which could be explained by the projects objective to align EOSC relevant initiatives within the Nordic region, not directly providing a service for Nordic users, as several other NeIC-funded projects.

3.1.1 Our assessment

Our assessment is that NeIC has succeeded in coordinating the operations of the NT-1 facility. In NT-1, representation of user needs is adequate, and activities are aligned with the ambitions of the Nordic countries. However, there is a need to discuss long-term strategic ambitions of NT-1 since the infrastructure is expected to be crucial for high energy physics researchers in the Nordic until 2038. Evaluation data indicates that representation of users for developing new services is working quite well in NeIC projects. However, there is some uncertainty among key stakeholders whether the project portfolio as a whole has an adequate representation of users and if activities have been aligned with actual existing needs by its users (see also section 6.2.1).

3.2 NeIC as a platform for Nordic e-infrastructure communities

In NeIC's self-assessment, it is reported that the project portfolio covers a broad range of scientific domains, technologies, and services, in which access to e-infrastructure and scientific computing plays an essential role. The current portfolio consists of seven active projects and activities, one project in preparation, two pre-studies, and ten affiliates, of which two are so-called extended affiliates (one year extension of the project to facilitate the full transfer of the project results).[30]

NeIC uses the Tietoevry's Practical Project Steering (PPS) model for managing projects and activities. According to NeIC's self-assessment, this should ensure a consistent project management process throughout NeIC's project portfolio and should contribute to the overall quality of NeIC's work.[31]

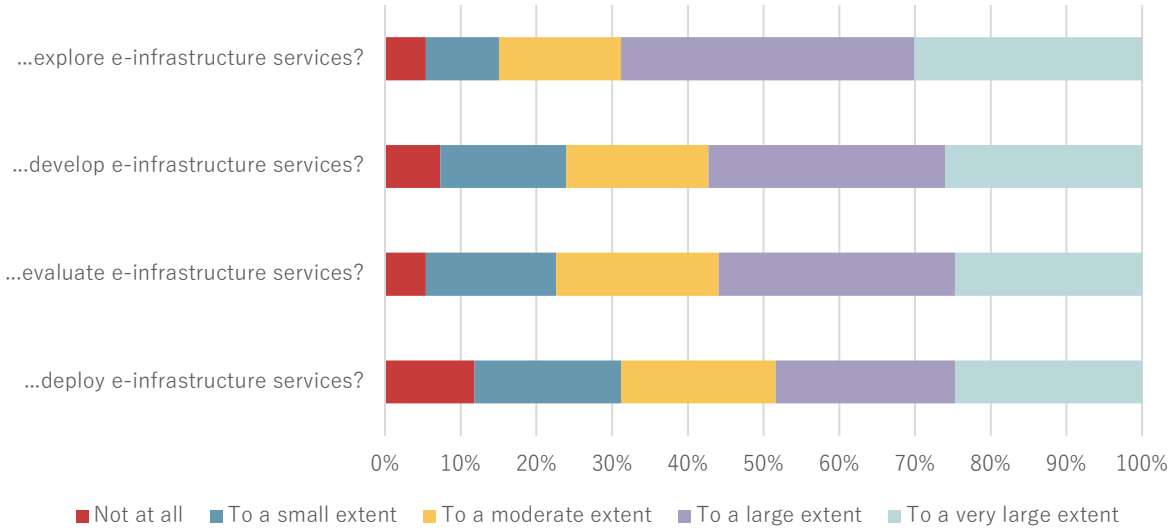
Figure 3 illustrates to what extent respondents believe NeIC projects offer platforms/activities where Nordic e-infrastructure communities can explore, develop, evaluate, or deploy services. The survey data indicate that most respondents generally consider NeIC projects to be successful in

[30] NeIC Self-assessment 2022

[31] NeIC Self-assessment 2022

offering such platforms for Nordic e-infrastructure. The deploy of innovative e-infrastructure services is considered to be offered to a lesser extent according to most respondents.

Figure 3 To what extent the projects offer platforms/activities where Nordic e-infrastructure communities can...



A broad range of projects has been initiated from annual open calls for collaborations. In general, the survey data indicates that the respondents consider projects funded by NeIC to be aligned with common strategic priorities of national e-infrastructure providers and their users. This is especially the case regarding offering platforms/activities to explore e-infrastructure services where close to 70% of respondents thought their project provided it to a large or very large degree, with PUHURI scoring highest (93%.) The PUHURI project is also successful in its objective of deploying and developing e-infrastructure services, as 75% of respondents claimed the project have offered platforms/activities to do this to a large or very large degree.

As represented in *Figure 3*, improvements can on a general basis be done regarding offering platforms/activities to deploy e-infrastructure services. Over 30 percent of the respondents did not at all, or to a small extent, consider their project to correspond with this statement.

Interview data shows that NeIC has some difficulties fully understanding the national objectives and strategies in e-infrastructure, and when national objectives and/or strategies have changed, NeIC did not fully adapt. This results sometimes in a lack of deployment of the outcomes/services of NeIC projects at national levels, affecting NeIC's effectiveness negatively.

Regarding EOSC-Nordic, one of its main objectives is to develop an infrastructure, providing its users with services promoting Open Science practices in Europe. Yet over 30 percent of respondents stated the project does not at all, or only to a small extent, offer platforms/activities to develop e-infrastructure services, indicating that the project does not achieve its objectives in that regard.

3.2.1 Our assessment

Our assessment is that NeIC has succeeded in being a platform for Nordic e-infrastructure communities to explore, evaluate, and develop innovative infrastructure services. However, NeIC has been less effective in deploying innovative infrastructure services in response to common strategic priorities within the Nordic region. NeIC's reduced ability to adapt to changes in national objectives and strategies in e-infrastructure might affect the deployment of the services of NeIC projects at national levels negatively.

NeIC has established appropriate and well-functioning mechanisms to foster both collaboration (pre-studys, workshops) and sustainability (affiliate programme). There are without doubt several examples of efficient project management, monitoring activities and successful collaborations.

4 Relevance

This chapter explores whether NeIC's organisational set-up has been a good model for the collaboration, and if activities are aligned with actual existing needs by its users and strategic priorities by NeIC-stakeholders.

4.1 NeIC's distributed set-up – a good model for cooperation?

According to the NeIC self-assessment and interviews with the NeIC secretariat there are various benefits for NeIC being a distributed organisation. The benefit of such an organisation is that NeIC can take advantage of the competence where it is and can develop the competence where it is: "Experts working with NeIC's activities and projects are members of different organisations that can learn and share new perspectives and practises with their colleagues within and outside of NeIC. They are members of different national communities and have contacts with various user communities which, in many cases, leads to users having local support in their use of the services developed in NeIC's projects."[32] Furthermore, the self-assessment stress that "communities can influence the future of Nordic e-infrastructure and propose development projects as distributed consortia, as opposed to having to collect all of the required expertise in a single institution."[33]

Interviews point out that advantages of a co-location would probably be a stronger cooperation and more creativity, but this must be weighed against the consideration that all the Nordic countries must be able to benefit. A potential risk with physical co-location is that it could lead to NeIC being perceived as a competitor to the national players.

NeIC has been assessed by the Research Council of Norway (2016 and 2020) and the Academy of Finland (2017, 2018, 2021) in connection with the national membership fee applications. These assessments concluded that the NeIC management was well established and fully adequate for optimising the strategy-led decisions of e-infrastructure. Interviews with NeIC stakeholders confirms that the distributed organisational set-up of NeIC, including the administration/secretariat, has been a good model for the collaboration in general. There are no actual complaints on NeIC's organisation, management, or project management. Several key stakeholders states that it is a strong value in NeIC's and NordForsk's secretariat being co-located, leading to synergies, and strengthening the organisational connection.

NeIC project managers confirms that NeIC's organisational setup has been beneficial. It has contributed to the development of management skills and the opportunity for project managers to

[32] NeIC Self-assessment 2022

[33] NeIC Self-assessment 2022

exchange experiences. In contrast, a few interviewees states that NeIC could facilitate more opportunities for stakeholders to exchange knowledge and experiences. One project manager said:

> *Having working groups based on thematic areas could be a good way strengthen knowledge transfer and to find new solutions. We should dedicate some more time on this. Today these exchanges often occur outside the meetings and are more on individual basis.*

Regarding the NT-1 organisation, interviewed NeIC stakeholders also argue that the distributed organisation has been a good model to handle services and promote sustainable support through NT-1. NT-1 has a distributed organisation across five countries and seven computing centres: CSC and the Helsinki Institute of Physics in Finland, HPC2N in Sweden, the Niels Bohr Institute in Denmark, the National Supercomputer Centre (NSC) in Sweden, the University of Bergen and University of Oslo in Norway, and SiGNET, the Slovenian Grid NETwork. All countries contribute to storage and computing resources via university computing centres and national resource providers such as SNIC, CSC, DeiC, and Sigma2.

4.1.1 Our assessment

Our assessment is that the distributed organisational set-up of NeIC has been a good model for the collaboration, both for NeIC Board, director, and employees, and NordForsk, as well as NT-1 and projects. Evaluation data indicates that NeIC has been a good model for various reasons, but mainly because a distributed organisational set-up helps keep the costs down and that being able to share competences creates an added value. The distributed setup facilitates cooperation between relevant stakeholders in a sufficient manner. However, NeIC could offer more opportunities for stakeholders to exchange knowledge and experiences.

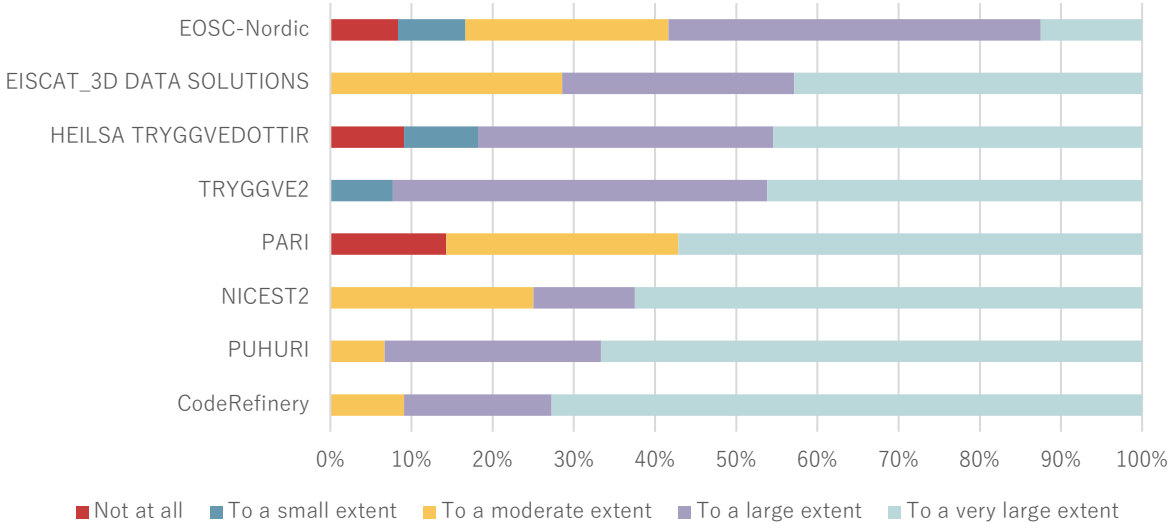
4.2 Alignment with user needs and expectations

The assessments of NeIC by the Research Council of Norway and the Academy of Finland, in connection with the national membership fee applications, raised the concern that user needs, in projects other than NT-1, may not have always been considered sufficiently. To address this, NeIC, among other things, holds annual direct meetings with each of the national partners to discuss NeIC's contribution to national initiatives and to gather feedback from the national providers. For research support personnel and e-infrastructure specialists, NeIC provides training programmes, and in some projects, they engage researchers in use cases or pilot projects.[34]

[34] NeIC Self-assessment 2022

Figure 4 illustrates to what extent respondents to the survey consider their project to be aligned with users' needs. 77 percent of the respondents stated that this was the case to a large or a very large extent. In general, all the projects showed positive results, with CODEREFINARY and PUHURI considered to be aligned with the users the most.

Figure 4 To what extent the projects are aligned with actual existing needs by users.



These findings were also confirmed in several interviews with project leaders in NeIC. One project leader pointed out that while the users themselves generally were not engaged in the decision-making process itself, the steering group has had contact regularly with users, such as researchers, to gather their perspective and needs. Furthermore, reference groups within several projects function as a support for this as well. A similar statement was done by another project leader. The project leader stated that the steering group naturally reflects the needs of users, and that the reference group functions as further support.

PARI

The Nordic e-Infrastructure Collaboration on Pandemic Research Infrastructure (PARI) was launched 1 November 2020 and ended 31 October 2021. The project was in response to the COVID-19 pandemic with the purpose of strengthening the Nordic country's ability to handle the effects of the COVID-pandemic and future pandemics. The core partners of the project were NeIC, UiO, UiB, DTU, ETAIS, de.NBI and NBIS, and the observing partners were Sigma2, SNIC and CSC-IT.

PARI collaborated with mainly Nordic and Estonian national providers, enabling easy access to datasets and dialogue between researchers and national providers. More specifically, PARI has three main objectives: 1. to facilitate collection and storage of data related to COVID-19, 2. to facilitate Nordic analysis of Nordic pandemic data using Galaxy and a research e-infrastructure in the Nordics and 3. to secure cloud infrastructure for sharing and presentation of pandemic research datasets and results.

The main expected benefit of PARI is that it will increase the facilitation of pandemic research data in the Nordic region. PARI reached all its main objectives listed above. Some concrete results from the project were a collaboration with NIPH regarding raw sequence reads that was submitted to ENA contributing to high quality submission guidelines work, a code software to deploy a Galaxy instance with Covid-19 specific workflows and the setup of a Galaxy server within a secure cloud environment. The total budget of the project was NOK 4,6 million, out of which NeIC contributed with 57 percent.

A limitation of PARI mentioned in the project plan was that the project did not own any e-infrastructure hardware which hindered NeICs objective of improving and advancing e-infrastructure. Regarding long-term sustainability, PARI shows different results. During the project, many collaborations with health research organisations were established, such as the collaboration with NIPH, which indicates that the results of the project could be lasting in the long term. At the same time, the plan for sequencing and making data public within GISAID was stalled in Denmark as their national strategy could not be combined with the project.

A concern raised in the assessments of NeIC by Research Council of Norway and the Academy of Finland was the lack of a mechanism for ensuring that NeIC's development projects are firmly anchored in the research e-infrastructure priorities and strategic plans of the national research funding agencies. To address this NeIC provides open calls for collaborative development projects to ensure that proposals are rooted in user needs, in a bottom-up approach. In this process, national e-infrastructure providers can prioritise submitted proposals to NeIC's open calls and thereby ensure alignment with national infrastructure strategies.[35]

The selection of new collaboration projects through open calls using a competitive process is, according to evaluations by national research councils, also aligned with international best practices, and addressing user needs for developing services.[36] However, in an interview, one NRICC member indicated an uncertainty of NeIC's user relevance:

[35] NeIC Self-assessment 2022

[36] NeIC Self-assessment 2022

We have questions about NeIC's user relevance and needs. There are open calls but how is user needs really considered? But it is difficult to measure user needs of e-infrastructure.

NeIC's links to the Nordic national e-infrastructure providers goes through the providers representation in the NeIC Board. In addition, NeIC hosts a provider forum – an advisory body consisting of senior experts from the national e-infrastructure provider organisations. This forum resembles a project reference group. According to NeIC's self-assessment, the provider forum is an important link between NeIC and the organisations and provides the executive team with valuable input from the national communities' perspectives and strategies.[37]

Regarding if NeIC's strategy, plans for activities and performance are aligned with the expectations of creating NAV and other higher-level strategies of the NeIC-stakeholders, one representative of the national providers stated that there is no NeIC funding activities that would just benefit one country, indicating that the activities add value, not just to a specific country, but to the Nordic region. Further, several project leaders also confirms that the objectives would not have been reached at all, or to the same extent, if the projects were solely run at national level.

However, some issues have been raised. One project leader said that it is sometimes hard to align national strategies with NeIC as it is difficult to agree on certain issues, e.g., the strategic direction of the project or to what extent the national providers should contribute. This becomes clear by statements from some of the representatives of the national providers. One such representative mentioned that NeIC has a difficult time in understanding the national strategies, and that a clearer strategic framework is necessary for NeIC. Although, another representative of the national providers said that the steering group tries to see the overall picture and does this in a good manner. The difficulties for NeIC alignment to national strategies is confirmed in interviews with the NeIC secretariat. However, the explanation given is not a lack of a strategy process and ambition to align, rather it's because of differences in the Nordic countries e-infrastructure landscape – "a fruit basket of apples, pears and bananas" – and national developments which risk making the NeIC's strategy outdated and less relevant.

Another project leader also mentioned that increased support from NeIC in some areas such as legal support was needed. More specifically, GDPR was brought up as an example, that more support on how to distribute data in a GDPR-friendly way would be beneficial.

[37] NeIC Self-assessment 2022

4.2.1 Our assessment

Our assessment is that Nordic user needs are represented in the current organisation structure of NeIC and projects are in general aligned with actual existing needs by its users. However, because of developments in the Nordic Countries e-infrastructure landscape and NeIC's lack of a clear strategic mandate and difficulties to adapt, NeIC's plans, strategy, and project portofolio might not always be aligned with higher-level strategies and/or expectations of the national NeIC-stakeholders. This also affects NeIC's alignment of activities and performance in relation to the possibilities of creating NAV.

5 Impact

In this chapter we evaluate how NeIC has created or contributed to impact on NAV, excellent science (through research and research e-infrastructures) and to the national level, the Nordic region and beyond.

We do not assess societal impact or economic impact within this evaluation but note that NeIC focusses primarily on science and that sharing knowledge and providing services to the private sector (R&D intensive business) is not within the activities of NeIC. Other HPC and e-infrastructures in Europe that Technopolis Group evaluated or advised before, focused more explicitly on such wider impacts to leverage funding and to contribute to a wider uptake of their HPC, data and cloud services across society to legitimate their role.

5.1 Contributing to Nordic Added Value

Contributing to creating NAV is key to success and an expected outcome of NeIC activities. From an evaluator's perspective, added value is the effect of an international or collaborative intervention, such as NeIC and its projects, over what could have been expected from an intervention at national or individual level, in this case in one of the Nordic countries.

NAV is defined as a central expected outcome of all NeIC's activities in the 2020-2025 strategy.[38] The strategy contains a framework to achieve NAV through NeIC's activities (see Table 3). The major elements of the strategic framework for NeIC's activities are enabling excellence in research, adding value beyond national capabilities, increase competence and competitiveness and to be a global role model for e-infrastructure collaborations. The framework thus provides various pathways to NAV for the project and activities of NeIC.

The assessment of NAV in the projects takes place in the third (separate) phase in the project selection process[39]:

- Assessment of quality and significance of the project by the external review committee
- Assessment of relevance in relation to national strategies by the national e-infrastructure providers
- Assessment of NAV and the alignment with NeIC's strategy by NeIC's director

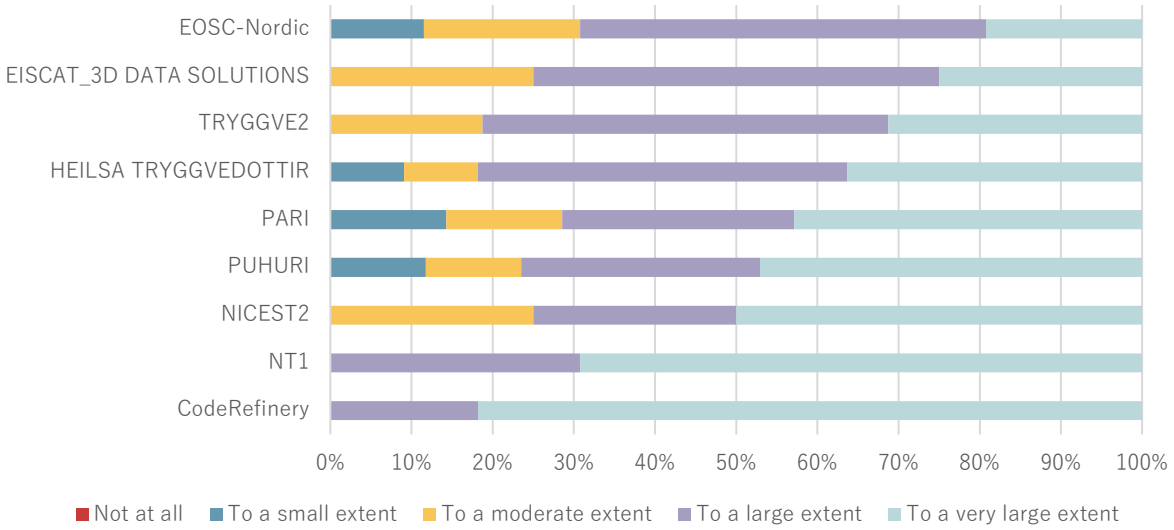
The perceived contribution of NeIC's projects to NAV varies among projects but is overall positive based on the survey among stakeholders. As depicted in *Figure 5*, a large majority of respondents

[38] NeIC Community Wiki

[39] NeIC self-assessment 2022

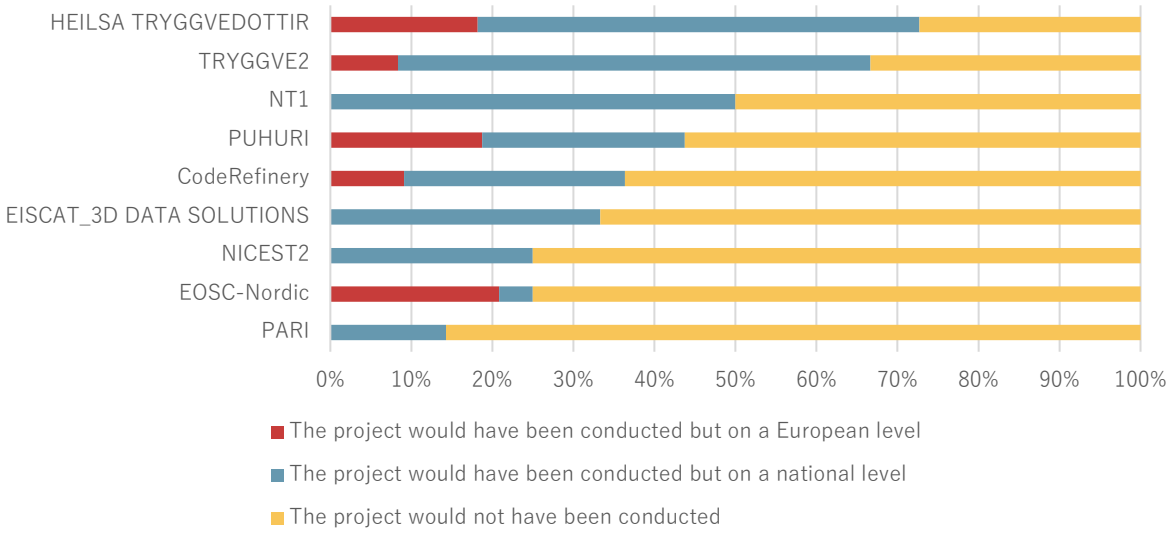
believe that the projects of NeIC contribute to a large or very large extent to NAV. CODEREFINARY and NT-1 are most positively assessed in that respect, while PARI and EOSC-Nordic are most critically assessed – with up to 30% of respondents indicating a small or moderate contribution to NAV.

Figure 5 To what extent the projects contribute to the creation of Nordic added value.



Asking the consequence of stopping an intervention usually provides good indications for added value. In the survey, stakeholders responded to the question what would have happened to the project if they were not jointly funded through NeIC? This sheds light on how well NeIC has succeeded in adding value to the Nordics beyond national, or European, capabilities in e-infrastructure. The response is depicted in *Figure 6.*

Figure 6 What would have happened to the projects if they were not jointly run and funded through NeIC?



In total, 60% of respondents active in projects stated that their projects would not have been conducted if they were not jointly run and funded through NeIC, indicating that NeIC to a large degree brings value beyond national or European capabilities in e-infrastructure. However, in TRYGGVE2 and its follow-up project, HEILSA TRYGGVEDOTTIR, 58% and 55% of respondents respectively answered that the project without NeIC would have been run on a national level. Whether these projects would have reached their objectives to the same extent if run on a national level is difficult to assess, but it indicates a lack of contribution to NAV.

HEILSA TRYGGVEDOTTIR

HEILSA TRYGGVEDOTTIR is a collaborative project on sensitive data which started 15 June 2021 and is expected to end 14 June 2024, with the overall aim to productise the technology developed in the former TRYGGVE projects and use that to increase interoperability and strengthen Nordic cross-border e-infrastructure.

The project is in its third phase and builds on the projects TRYGGVE and TRYGGVE2. Participating partners in the project are NeIC, ELIXIR nodes in Norway, Denmark, Sweden, Finland and ETAIS in Estonia. The total budget of the project is approximately NOK 35,3 million, out of which NeIC contributes with around 50 percent of the funding.

To achieve its overarching aim, the project is structured into two work packages. The first aims at creating an operational ecosystem that meets researchers needs for sensitive data analysis. The second aims at creating open genome/phenome datasets and link the activities to the scientist's actual work bench.

To reach the objectives of the project, several activities are planned within the two work packages. The two highest prioritised activities in each work package are to make federated services operational across at least three HEILSA TRYGGVEDOTTIR partners and to make sure Denmark and Estonia have the technical capability to develop and deploy NeICs Sensitive Data Archive, and regarding the second work package: to establish a framework for country-specific synthetic dataset creation and to create simulated datasets suitable for technical validation of FEGA data deposition and researcher training. As the project

Interview data largely confirms the findings depicted in *Figure 5*. Almost all project leaders indicates that their projects would not have been possible on national level and that joining expertise from different countries has been essential for the project's development. One project leader said that:

> *The project wouldn't work out that well on a national level, we are scaling up outside the national context and other organisations need to duplicate this work.*

However, interviewees with NRICC and NordForsk signal an uncertainty of what value NeIC brings and questioned if a Nordic collaboration within e-infrastructure could be organised in a different way. One NRICC member said:

> *Had someone else been able to do what NeIC does? That is what we ask ourselves. We are not sure who that "else" would be. [···] It is generally hard to know what the added value is.*

The response for NT-1 and PARI in *Figure* 6 is rather contradictory to the assessment of respondents on the creation of NAV in *Figure 5*. A large majority of respondents believes NT-1

contributes to a large extent to the creation of NAV, while also 50% of respondents believe that NT-1 would have been conducted at national level as well – signalling a lower added value. Similarly, a large majority of respondents believe PARI would not have been conducted without being funded by NeIC, while almost 30% of respondents believe PARI to only contribute to a small or moderate extent to the creation of NAV.

In interviews, various stakeholders commented that NT-1 – the main activity of NeIC – would have contributed to NAV with or without NeIC's support. One steering group member said:

> *If NT-1 had not been run by NeIC, NeIC would not have existed in the first place, some other form of Nordic collaboration structure would have been formed instead. The same applies for if NeIC would stop its NT-1 funding, a different cross-Nordic organisation would have to be created to support NT-1.*

Another steering group member confirmed the statement saying that if NeIC was not supporting NT-1, it would presumably been run as an independent Nordic project, like it did before the establishment of NeIC. As NT-1 is the backbone and the reason for NeIC being formed, this indicates that without NT-1, NeICs contribution to NAV would have been smaller than it currently is. One NRICC member says that NeIC overall is successful in creating NAV and that NT-1 largely contributes to it. However, another NRICC member problematised it and said:

> *NT-1, I think it is an added value in it being jointly run by Nordic countries. There are good projects as well, but we sometimes have issues seeing the added value there. We want to see what the added value is for our researchers, who are the end users.*

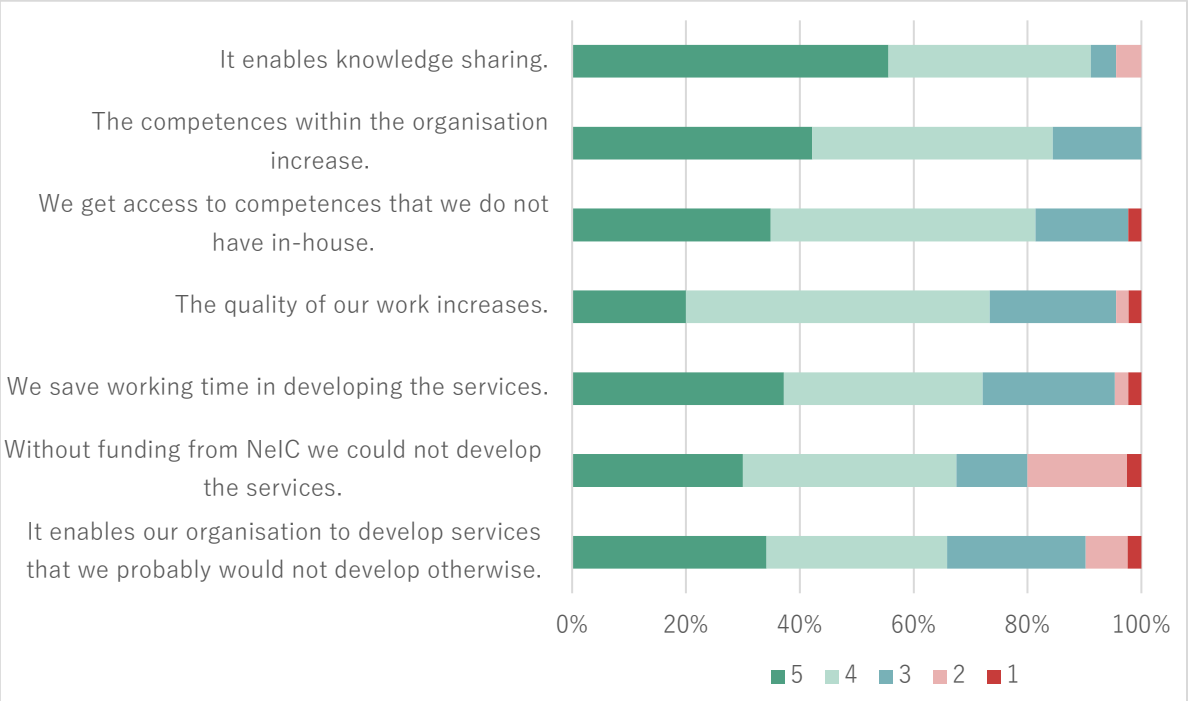
Through various projects and activities within NeIC researchers from across the Nordics interact and collaborate, sharing knowledge and strengthening each other's research capacities and contributing to new solutions and services. NeIC has successfully increased its number of partners in various collaboration projects since 2017, from 41 to 49 in 2021, but more importantly the number of people affiliated with NeIC and its projects increased significantly since 2017, from 198 to 322 in 2021.[40]

The benefits of working together within NeIC has been assessed in a survey among partners and collaborators of NeIC's projects (N = 47) and was conducted by NeIC in 2020. The results, presented in *Figure* 7, shows that a large majority of respondents agrees (4) or even strongly agrees (5) with the various benefits. It is most strongly felt that knowledge sharing, increase of competences and

[40] Data from NeIC's self-assessment

access to competences that are not available within the own organisation are a clear benefit of the collaboration in NeIC. It is these elements that NeIC adds value through its projects. Also here, a majority believes that services developed within NeIC would not have been developed otherwise – providing an indication for added value.

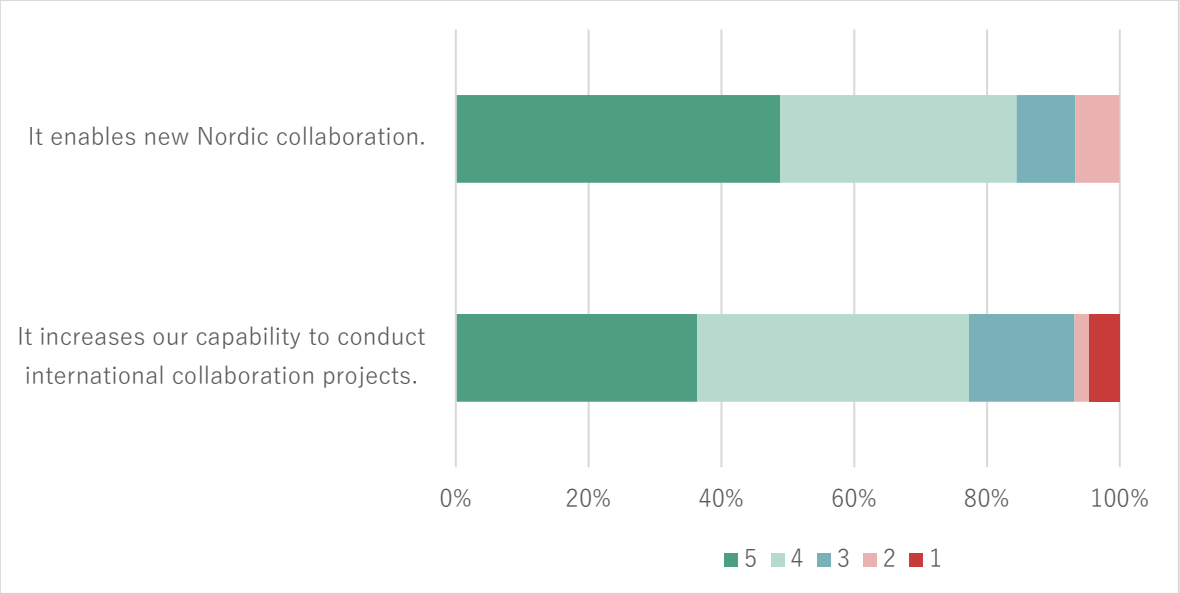
Figure 7 How does the Nordic collaboration that NeIC facilitates benefit your work?



Source: NeIC (2020). Legend: 5 = *? 5= strongly agree, 4= agree, 3= neither agree nor disagree, 2= disagree, 1= strongly disagree.*

NeIC reports that collaboration in projects also leads to further collaboration in other projects and programmes at European level. As such, collaboration within NeIC can be considered as a springboard to a higher, more competitive international level for which track and the right partners from multiple countries are generally very important. *Figure* 8 presents how NeIC's project partners and collaborators perceive how NeIC projects contribute to other collaborations. A large majority of respondents agrees (4) or even strongly agrees (5) that it has enabled new Nordic collaborations and increased capabilities to conduct international collaboration projects.

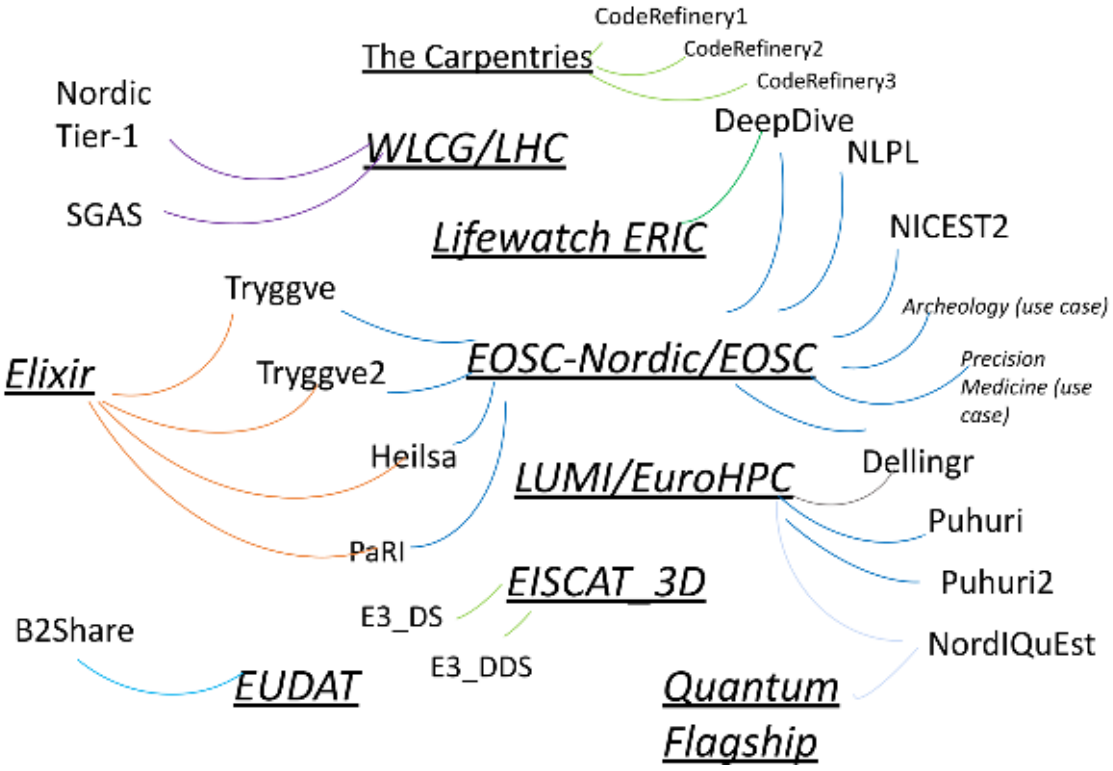
Figure 8 How has being involved with the NeIC project affected your other collaborations?



Source: NeIC (2020). Legend: *5= strongly agree, 4= agree, 3= neither agree nor disagree, 2= disagree, 1= strongly disagree.*

Collaborations and projects within NeIC has contributed to European and international collaborations. In that sense NeIC has been a springboard to wider international collaboration, which can be seen as an added value, but could also contribute to research excellence given the more competitive nature of international projects and the gained access to various European Research Infrastructures (e.g., LifeWatch, LUMI and EOSC) through NeIC. In *Figure* 9 NeIC has indicated the relation between its projects and European/international projects.

Figure 9 Connections between NeIC projects and European and international initiatives



Source: self-assessment NeIC (2022). Legend: European and international projects are underlined.

5.1.1 Our assessment

NeIC contributes to NAV as a platform for collaboration on e-infrastructure. Various project and activities under NeIC would most likely not have been conducted without the existence of NeIC and many projects are perceived as providing NAV. However, NeIC's presented results on NAV are somewhat unsystematic and anecdotal.

There is a strong consensus among key stakeholders that NAV is anchored and understood regarding NT-1, but more varied regarding several of the other projects in NeIC's portfolio according to the project leaders in the survey. This variety is an indication that there is room for continued attention to NAV in the management of the portfolio and selection of new projects. The main building-blocks of NAV in projects and activities, as identified by the stakeholders, relates more to capacity and competence building and ability to create and run attractive platforms for Nordic and international collaborations, rather than supporting increased scientific excellence more directly. But this can also relate to communication and an increased potential to gear up strategic communication of results/impact of NeIC activities and services.

NeIC provides a convenient layer between the national level and the wider international or European level, acting as a steppingstone to competitive European research projects and infrastructures. Although involvement in such projects may have occurred otherwise, project partners do recognise

NeIC's role. Generally, one should not underestimate the role of previous international collaboration in successful consortium forming and application for competitive international projects.

5.2 Contribution to research and research e-infrastructures

According to NeIC's self-evaluation, the contribution of NeIC to research and e-infrastructures is through:

- **Developing and enhancing research software and technology:** according to NeIC it has contributed to competitive solutions for researchers in the Nordic countries (e.g. new software, services and solutions fostering interoperability in the Nordic region), cross-Nordic collaboration (e.g. projects must include 3 countries), contribution to national e-infrastructure strategic priorities and roadmaps (e.g. proposals assessed by national e-infrastructure providers on contribution to national strategies). Examples are the TRYGGVE projects, delivering federated genome data management service where sensitive data can be stored within national borders and metadata is available internationally.
- **Offering services for research via NT-1 and projects:** NT-1 is the only operational service provided by NeIC and ranked top-3 Tier-1 facility by WLCG in 2020. It promotes excellence in research by providing access to LHC data WLCG resources worldwide and high-performance computing. It is used by 150 Nordic users and 7000 users worldwide. Development projects, pilots and use cases enable Nordic researchers to use and benefit from services in development.
- **Building competencies and promoting Open Science:** NeIC has taken up a role in Open Science, especially regarding data, by providing training programmes and participating in the European Open Science Cloud with the aim to build competencies in and promote Open Science. Training programmes focussed for instance on improving and sharing code openly within CODEREFINARY and on FAIR data management, improving the quality and reusability (open) research data. According to NeIC, these training events have in total attracted over 2.000 participants across the Nordics.

TRYGGVE2

TRYGGVE2 (2017–2020) was the second phase of the TRYGGVE project. The idea of TRYGGVE2was to advance the development of international e-infrastructure for sensitive personal data for biomedical research. Other objectives of the project were to leverage the Nordic cloud resources for sensitive data processing and use the Nordic expert collaboration network assembled during TRYGGVE to make the services easily accessible across countries, to expand the number use cases arising from the stakeholders and to conduct active outreach and dialogue with European and international initiatives. Some of the participating organisations were national e-infrastructure providers such as SNIC, CSC, DTU and UiO, and other organisations, such as NeIC, ELIXIR and the Nordic Council of Ministers.

The outcome of the project was positive. Some concrete examples were the deployment and establishment of European Genome-phenome Archive (EGA) Nordic nodes in Finland, Norway and Sweden, the establishment of procedures for data and workflow mobility across the Nordic countries, a support for 24 use cases and making REMS compliant with the GA4GH passport standard, thereby making it feasible for use in a federated authorization framework. Because of the success of the project, two other projects were initiated: PARI and HEILSA TRYGGVEDOTTIR.

An improvement for future projects mentioned in the final report, was that it is essential to align the project objective with the partners organisations. Otherwise, for example, ELIXIR nodes, which are required to support their national research, may have to prioritize their national objectives above the project objectives.

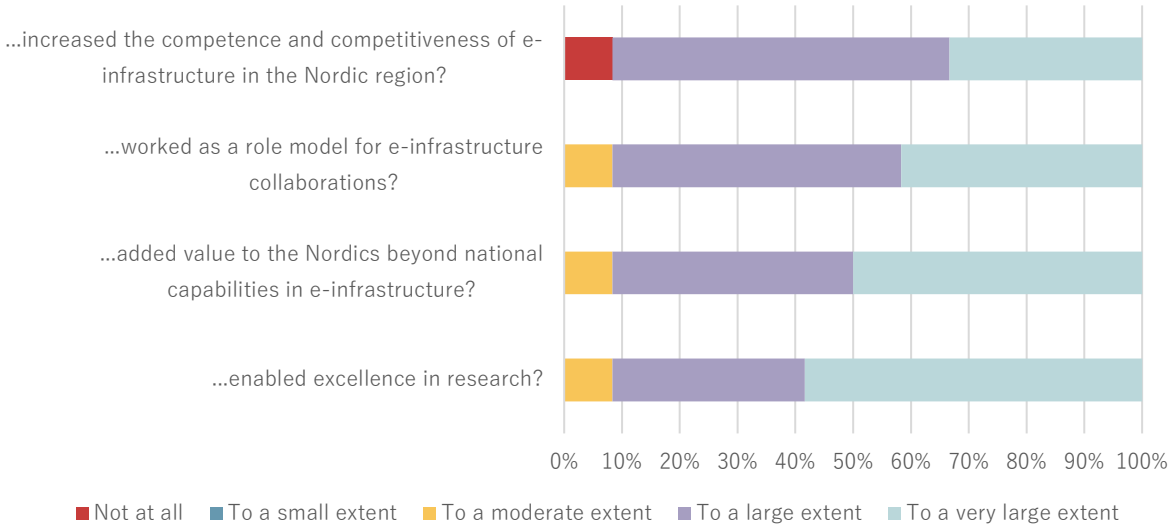
NeIC's contribution to research and research e-infrastructures is through its projects and activities that should promote excellent science. In NeIC's policy for project selection scientific excellence is stated as the main expected benefit.[41] Projects should contribute to scientific excellence in terms of better research quality of improved productivity of researchers. Before their start, projects are thus assessed on their contribution to scientific excellence, providing a framework to steer on this impact.

According to stakeholders, NeIC has contributed through its activities to research excellence. Especially the NT-1 project is recognised as a contributor to or enabler for excellent science: 92% of respondents to the survey indicate that NT-1 has enabled to a large or very large degree excellence in science. For the other projects within NeIC, overall 59% of respondents indicated that the projects enabled to a large or very large extent excellent science. This is still a majority but is less convincing than for NT-1. An example of NT-1's contribution to excellence in science, brought up by a member of the NCLG committee, is the discovery of the Higgs boson[42], which was only possible due to the Tier-1 and Tier-2 centres. The survey response is provided in *Figure 10* and *Figure 11.*

[41] NeIC self-assessment 2022

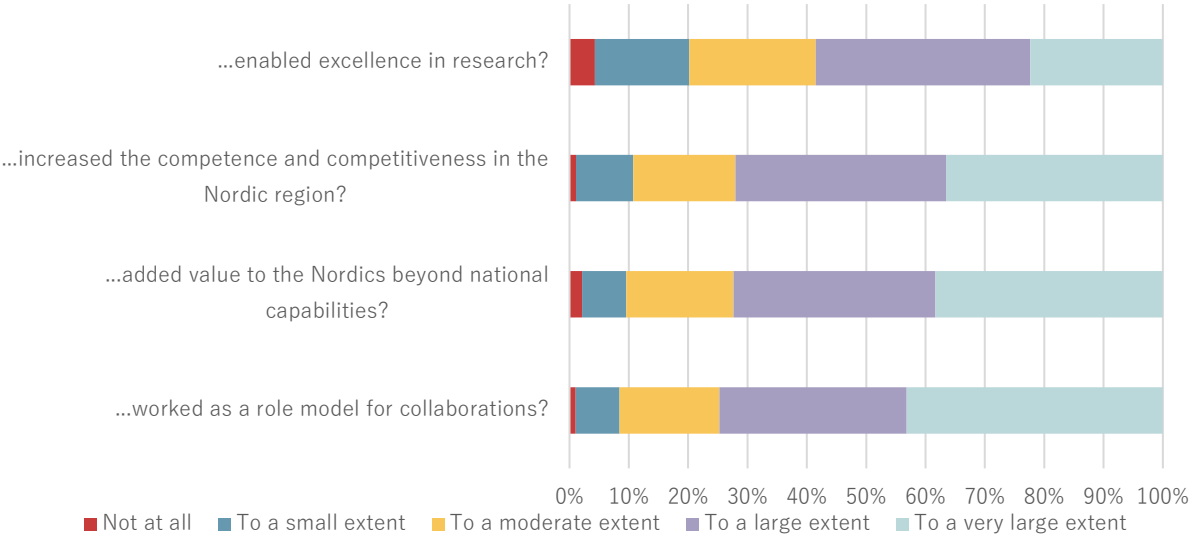
[42] https://home.cern/science/physics/higgs-boson

Figure 10 To what extent has the NT-1



Whether the project has enabled excellence in research has been difficult to assess by survey respondents in some cases as many projects are ongoing or the technology developed within the projects haven't been put to full use yet. This was the case with the project EISCAT_3D DATA SOLUTIONS where one team member made a point of saying that the question was too early to answer since the instrument first can be used in a couple of years.

Figure 11 To what extent has the projects



EISCAT_3D DATA SOLUTIONS

EISCAT_3D DATA SOLUTIONS (E3DDS) (2018–2019) has its background in the international organisation EISCAT (European Incoherent Scatter Scientific Association), that was formed in 1975 with the purpose of developing an incoherent scatter radar for the Northern auroral zone. EISCAT_3D in turn is the next generation of this technology, with fully digital signal processing that will enable comprehensive three-dimensional vector observations of the atmosphere and ionosphere above Northern Scandinavia.

The idea behind E3DDS was to design and prototype the data flow and computing workflow, from the antenna arrays of the upcoming EISCAT_3D radar sites, to the central storage and computing site. The overall objective of E3DDS was to simulate the data chain from the First Stage Receive Units to the File Writers, that write out the narrow beam data files, to be sent to off-site storage. Further, E3DDS had four deliverables: 1. On-site computing software and hardware architecture recommendation, 2. On-site data processing simulation, 3. Cluster management for EISCAT_3D and 4. Investigate potential synergies with NT-1.

The participating organisations were EISCAT, SNIC, CSC, Sigma, NORDUnet and NeIC. The project had a total budget of NOK 2,9 million where NeIC financed 5,5 percent of the amount. During the projects lifespan several activities were conducted, e.g., testing of online software on hardware provided by NT-1 partners and national providers. The activity resulted in a clearer illustration of what was required for production of EISCAT_3D online computing, which in turn led to it being easier to set pricing levels for the service.

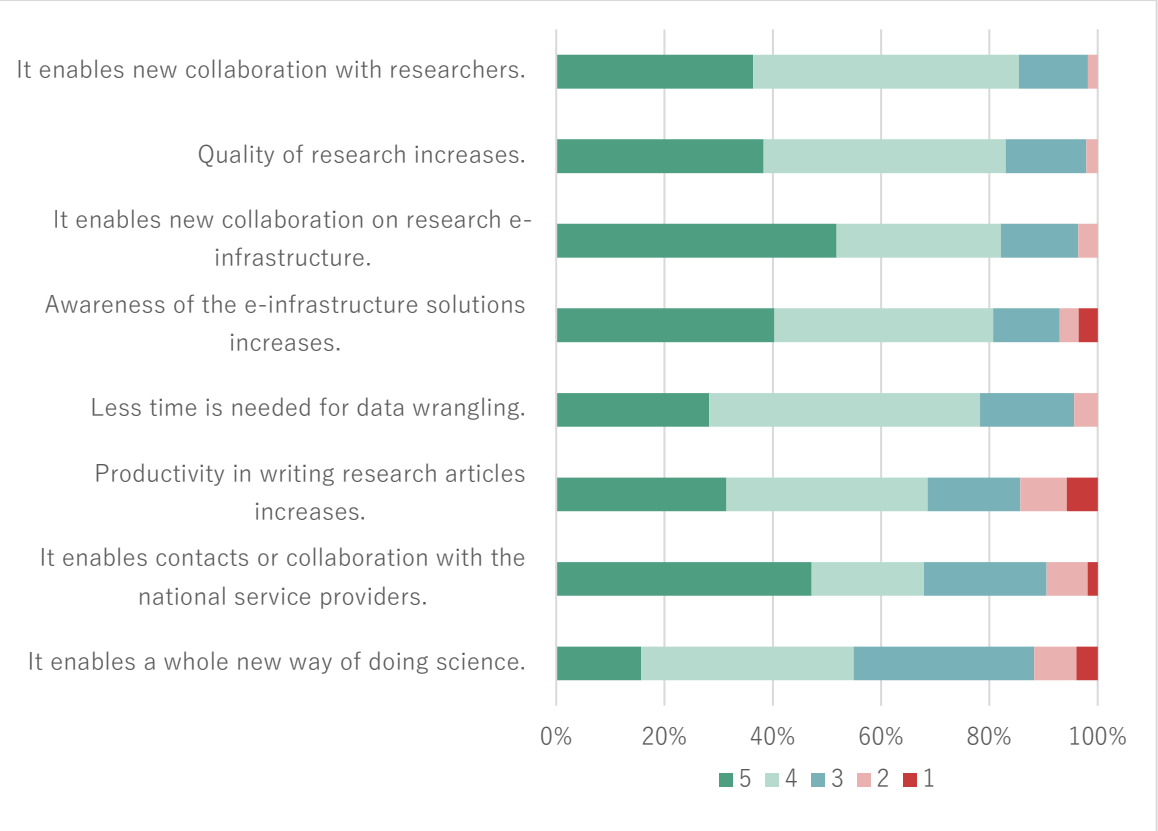
Another project, EOSC-Nordic, have by far the lowest score regarding enabling excellence in research. An explanation for this is provided by a steering group member:

> *EOSC-Nordic enhance the tools enabling excellence in research – which is why the project in itself does not as such create excellence in research. The project creates frontrunners among research users, who then will create excellence but research excellence cannot be expected out of a 3-year infrastructure project – however, it is the long-term ambitions for the EOSC-Nordic activities.*

The projects contribution to excellence in research is in other words more indirect. According to NeIC's stakeholder survey, about 80% of the respondents said that NeIC enables new collaborations with researchers and on e-infrastructure solutions, increases the quality of research and awareness of e-infrastructure solutions, and decreases the time spent on data wrangling (see *Figure 12*).[43] Although still a majority, less respondents agreed clearly with the views that NeIC increases productivity in writing research articles, enables contacts or collaboration with national service providers or enables whole new way of doing science. Overall, the response from NeIC's stakeholder survey is positive regarding aspects of excellence in science. While some project may be in an early stage, this is a clear indication that NeIC is contributing to research excellence.

[43] NeIC self-assessment 2022

Figure 12 How would you consider NeIC benefits research and collaboration?



Source: NeIC (2020). Legend: *5= strongly agree, 4= agree, 3= neither agree nor disagree, 2= disagree, 1= strongly disagree.*

Many project leaders confirm that NeIC is successful in facilitating open access and Open Science within their fields[44]. Several interviewees describe it as the main objective and core of NeIC's activities. One interviewee said that NeIC and its funded projects has led to the Nordic Earth System Modelling Community adopting Open Science practices. Furthermore, NeIC has also adopted an open-access repository, Zenodo, for publications produced in NeIC's projects.[45] While this is positive, how far the facilitation of open data and open access reaches is another question. One reference group member working in the TRYGGVE2 project points out that:

> *NeIC is doing great things, but they must develop plans for communicating their results and for the implementation of good pilots so that the provided services come to use. How many researchers know of NeIC and their services outside the*

[44] Open Science could indirectly also contribute to research excellence, as open research data could be reused, build upon and controlled (in terms of quality) by other scientists.

[45] NeIC self-assessment 2022

> *network? The results should reach the research community outside the already involved one, and investors should be presented with results so that they understand that the investment in NeIC is a good one and that they could use NeIC as a good example.*

While the survey data indicates that NeIC contributes to facilitating open data and open access, the results of this might thus not be accessible enough for people outside of NeIC's network. There were also issues brought up regarding open access and Open Science connected to NT-1. It was mentioned that the projects supported by NT-1, ATLAS, and ALICE, have their own data management policies which in some cases hinders open access. Furthermore, one representative of NT-1 said:

> *To have open access to our data is sort of a new concept and we therefore have no actual standards for it. We could be better there. We could facilitate open access by training people in these aspects. We have 135 data stewards connected to us, so we have a team. We can train people on how to make it FAIR. We need to do the work and ask the questions: is it findable, usable? At to what degree can we make the data accessible?*

Thus, while people generally think open access and Open Science are central parts within NeIC, there are improvements to be done.

NeIC has also been successful in increasing competence and competitiveness in e-infrastructure (see *Figure 10* and *Figure 11*). In the NeIC self-assessment, over 80% of the respondents stated that NeIC facilitates, give access to competences that they don't have, and that the competences within the organisation increase because of NeIC's collaborations.[46]

An issue related to all the points above, raised by a steering group member in the PARI project, was that the project only lasted a short time, thus hindering noticeable achievements (such as results related to excellence in research) to be seen. This issue does not concern NT-1 as it is an ongoing activity that is not expected to end anytime soon. On the other hand, interviews with project leaders indicates that projects such as PUHURI, which is expected to run for two years, lacks the right conditions to obtain excellence research results in such a short time frame.

Even though direct results from some of the projects are hard to measure, due to the services developed and provided to researchers in the projects, long standing effects achieved after the projects end, are probable.

[46] NeIC self-assessment 2022

5.2.1 Our assessment

Our general assessment is that NeIC to a large degree have succeeded in promoting scientific excellence within the Nordic region and beyond. This is most clearly stated regarding the NT-1 activities, but with a greater variety also in relation to several other projects. For some of these projects it is too early to notice impact on scientific excellence and for some, like EOSC-Nordic, this impact is more indirect. The fact that many projects relate to European projects, also provides an indication of a contribution to scientific excellence: being able to join competitive consortia. NeIC has installed a selection framework in which scientific excellence is assessed before a project is started, providing a tool to improve its impact on scientific excellence. NeIC has worked well to strengthen joint capabilities, and competencies (e.g., through trainings) and have contributed greatly to a fast-growing new paradigm of Open Science. NeIC must pay more attention to communicating its results and services and prioritize its reach outside the established NeIC-networks, to further improve and widen its impact on scientific excellence.

5.3 Contribution to the national level, the Nordic Region and beyond

In the self-assessment NeIC states that "NeIC as a community or organisation could be better known in our partner organisations. This has been recognised by NeIC's management, and strategic communication has recently been introduced in the strategy implementation plan."[47] Interview data indicate that NeIC is indeed not that well known outside its internal network. Key stakeholders point out that "it is a challenge that the knowledge and understanding of NeIC is too small" and that "most researchers have little knowledge or understanding of NeIC." This may however more signal lack of communication about NeIC and its offering to researchers and a lack of dissemination of the results of NeIC.

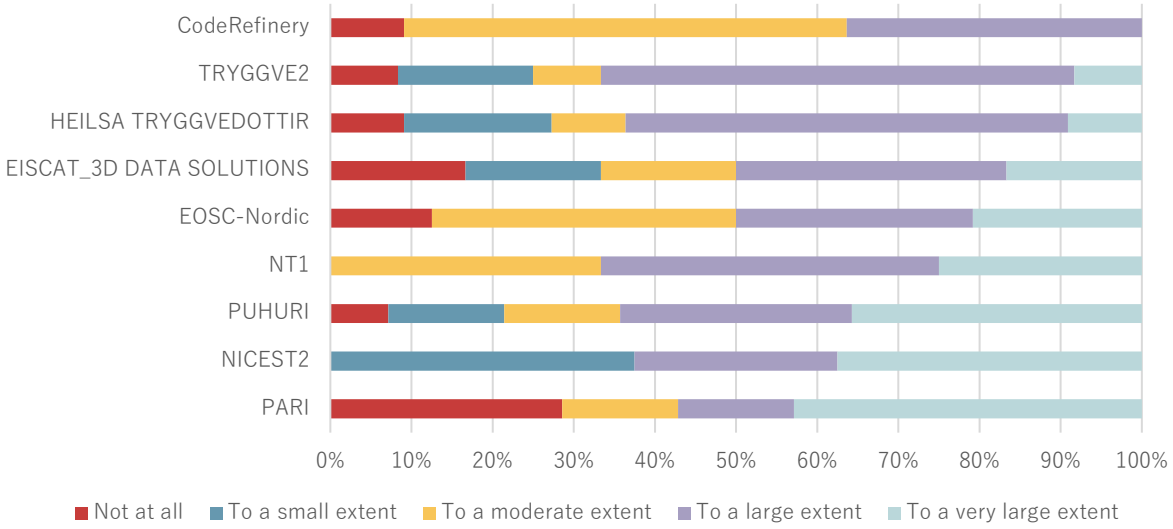
There are on the other hand examples where NeIC projects have created interest in other countries and regions. Regarding the EOSC-Nordic project, one steering group member said that EOSC-Nordic is ahead of EOSC development, acting as a role model for all of Europe. Further, other project leaders have stated that organisations in countries such as Slovenia, Croatia, Luxembourg, the Netherlands, UK, USA, Switzerland, Germany, Spain, Latvia, Italy, Australia and South Africa have shown interest in their projects and its outcomes.

It is difficult to find examples of NeIC's contributions to national higher-level infrastructure strategies in the Nordic region. Yet, as can be seen in *Figure* 13*,* which shows to what extent the survey respondents consider their projects to be contributing to national strategies in higher-level

[47] NeIC Self-assessment 2022

infrastructure, a majority of respondents in all projects except CODEREFINARY said their project had contributed to this to either a large or very large extent.

Figure 13 To what extent to projects have contributed to national strategies in higher-level infrastructure.



In the survey comments we were able to find some examples of contributions to national higher-level infrastructure strategies. Regarding NT-1, one steering group member said:

> *Swedish national storage for research data is a direct copy of the NT-1 solution. The distributed teams in Sigma2 have been built on NT-1 experience with distributed operations. The big data platforms like tape archives have been co-funded by NT-1 usage.*

Furthermore, one steering group member in the TRYGGVE2 project stated that national sensitive data providers, e.g., TSD and Bianca, have composed their Nordic strategies based on the experience collected in TRYGGVE. Statements done in the interviews also correspond with the results shown in *Figure 13*, and the survey comments above. One NeIC Board member said that even though it is not NeIC's role to influence national strategies, they organise meetings where representatives of the Nordic countries can discuss and exchange expertise, which probably is of value for the country's strategic development.

The contributions that NeIC as an organisation brings to its member-countries was also highlighted in a comment by a steering group member in the project NICEST2,

> *In some Nordic countries, there are infrastructure projects for the Earth System Modelling Community at national level. However, none of them operate successfully, despite efforts and much more funding. The reason is the lack of interaction with national providers, Research Software engineers and*

researchers. Within NeIC everyone has to work together towards same objective, while at national level researchers are not working with national provider staff. Within NeIC, we understand the challenge to 'mix' staff with different backgrounds and can try to tackle it and find concrete solution. At national level, this issue is not even identified so it cannot be tackled yet.

The statement indicates that, at least within the areas in which the NICEST2 project are involved, NeIC brings a significant contribution to national higher-level infrastructure, as it would not exist to the same extent without it.

NICEST2

The Nordic Collaboration on e-Infrastructures for Earth System Modeling (NICEST2) is an ongoing project (the second phase), with the aim of strengthening climate change modelling in the Nordic region. The project, which started 1 June 2020 and is expected to end on 31 May 2023, has a total budget of NOK 10 million, out of which NeIC contributes with 58 percent.

NICEST2 have two main objectives: firstly, to improve e-infrastructure to be able to reach its goal of developing ESM and publishing Findable Accessible Interoperable and Reusable (FAIR) climate data, and secondly, to set up building blocks for ESM workflows that will be deployed as part of EOSC.

The funding partners are NSC, Sigma2/UiO, FMI, MET Norway, NORCE, NERSC and CSC. The project also has several supporting partners: INAR, DMI, SMHI and TalTech MSI. Moreover, NICEST2 intends to collaborate with other projects and activities within NeIC such as PUHURI and NT-1.

Some of the project's achievements so far are a collaboration on the installation of the ESGF node, development of ESMs for use from Laptop to the LUMI supercomputer, with the aim of establishing FAIR climate tools and identification of potential bottlenecks that can impact the efficient usage of the Nordic ESMs on EuroHPC.

As the project is ongoing, results and the long-term effects of NICEST2 are currently difficult to identify, but estimations have been done. Scientific partners will directly benefit from the project as it will enable them to develop an expertise in three main areas: FAIR data, ESMValTool and future HPC. The national e-infrastructure provider partners will be able to utilise their resources more efficiently. Users of climate data will get access to FAIR climate data, and taxpayers in the Nordics could also benefit from this by better climate predictions and less waste of energy in the operation of HPC centres.

In the CODEREFINARY project, another issue was raised. One team member said that it is hard to assess how the project had contributed to the development of national strategies, mostly because of an uncertainty of how well research software is understood generally. If the services developed are not accessible/understood it decreases the potential benefits of the projects, and thus the contribution to national higher-level infrastructures decreases as well. Several NRICC members stated in interviews that NeIC must be more aligned with national strategies and priorities, that they have difficulties understanding the development on national and EU level and that the organisation must find a common Nordic ground due to the accelerating development pace of e-infrastructure services internationally.

NeIC has been the main tool for implementing the Nordic eScience Action Plan 2.0. The two Nordic eScience action plans have been guiding NeIC's activities over the years. The evaluation of the

effectiveness of NeIC in addressing the five action points that focus on e-infrastructure (in the Nordic eScience Action Plan 2.0.) that was conducted supports this assessment.[48]

5.3.1 Our assessment

Our assessment from the evaluation is that NeIC in individual cases has been recognized as a global/international role model for e-Infrastructure collaborations and in general contributed to the national higher-level infrastructure strategies in the Nordic region, even though it is difficult to identify concrete contributions. To be more successful, NeIC must be more aligned with national strategies and priorities (even though strategies and priorities on national level are not always clear) and the position and role of NeIC in the e-infrastructure landscape. Our assessment is that NeIC has very successfully contributed to both Nordic eScience action plans.

[48] https://wiki.neic.no/w/ext/img_auth.php/b/b5/Edited_e-Science_Action_Plan_evaluation.pdf

6 Sustainability

This chapter explores whether the benefits of NeIC will last, i.e., the sustainability of services beyond the project lifecycle, and If NeIC's governance, strategy, and action plans promote further development and are sustainable over time.

6.1 Projects

The assessment by the Research Council of Norway and the Academy of Finland, in connection with the national membership fee applications, stated a concern about the sustainability of the services. Since 2020, NeIC has made sustainability of the project's results a priority through its strategy. According to NeIC's self-assessment, sustainability is emphasised using benefit realisation management. This is a tool for managing project benefit that has been an integral part of NeIC's project life cycle since 2019. It is introduced to each new project in the start-up phase and continues throughout the project life cycle. According to the self-assessment, the benefit realisation management ensures quicker and more certain benefit realisation and more effective business exchanges. It also contributes to project portfolio management as it provides a basis for decisions regarding the initiation, continuance, and conclusion of projects. In the self-assessment NeIC states that the "ability to sustain project results has also been recognised as an area for improvement and actions to address this have already been made".[49]

The Affiliate Programme that was established in 2020 monitors the realisation of benefits and the impact of projects after they have been completed (transition of services). The purpose of this process is to ensure that the expected benefits are really achieved after the project deliveries have taken place. To make sure this happens, NeIC, through the benefit realisation management process, analyses the monetary benefits, the time benefits, and the quality benefits of every project. In 2021, an extended affiliate programme was introduced, providing financial support to the project consortium to enhance the sustainability of the project results.[50]

Interview data indicates that NeIC is progressing in terms of creating conditions for obtaining sustainability of project results, although there still is a lot of room for improvement. One project leader says that NeIC needs to be more operational and active after a service is developed. Other project leaders stated that NeIC needs to be more interlinked with NordForsk's funding to be able to evolve their work and engage with more stakeholders. Another interviewee consider that NeIC

[49] NeIC Self-assessment 2022

[50] NeIC Self-assessment 2022; https://wiki.neic.no/w/ext/img_auth.php/e/ea/NeIC-Policy-for-Benefits-Realization-Management_approved-Aug-2019_updated-Oct-2019.pdf

needs to be more oriented towards coordinating EU-funded projects. Several project managers states that NeIC should improve the support for starting affiliated projects. One project manager said:

> *NeIC has an affiliate program, where they provide funding to keep some projects going after its end date. They want some services that has been developed to evolve and keep it going. But I think that the funding for it is too small.*

There are some issues regarding the sustainability of current projects. For example, the results of the project CODEREFINARY have been considerably positive. CODEREFINARY received funding from NeIC, but is currently, largely sustained by volunteers, which could be a potential issue in relation to the project's sustainability.

NeIC is currently developing an implementation plan for enhancing NeIC's benefit realisation management with the framework for the transition services with pilot activities in NeIC projects. The aim of this is to create new opportunities for the projects and to increase the NAV of the projects.

CODEREFINARY

CODEREFINARY is an ongoing project, in its third phase. The project started in 2016 and is expected to end in 2025. The aim of the project is to teach students and researchers how to write better code and provide research groups with software development e-infrastructure tools to develop, review, discuss, test, and share their code. The participating organisations are Aalto University, CHCAA, CLAAUDIA, CSC, DeiC, ENCCS, ETAIS, SNIC, Sigma2 AS and USIT. The total budget of the third phase is approximately NOK 21,5 million, out of which NeIC contributes with around 22 percent of the amount.

The results of the project have been considerably positive. During phase-1 (2016-2018), the productivity of researchers was enhanced by the improvement of research software development and collaboration practices in the Nordic region. After 13 three-day workshops, about 80 percent of the participants stated that their code became more reusable and reproductible because of the workshops, while round 85 percent said that the workshops had facilitated more collaborations on software development. Since 2016, a total of 49 workshops and three instructor training events have been conducted with over 1400 participants.

Apart from the workshops, one of the projects core activities is to provide a code repository hosting service that is open and free for all researchers based in national universities and research institutes in the Nordic countries. Another main objective is to make the project sustainable in the future. During its two first phases, CODEREFINARY received funding from NeIC, but is currently, largely sustained by volunteers.

6.1.1 Our assessment

The sustainability of the services has been raised in interviews, in the self-assessment, and in national assessments of NeIC (i.e., by Academy of Finland and the Research Council of Norway). NeIC has recognised this as an area for improvement: NeIC's current strategy (since 2020) puts an emphasis on sustaining project results and our data shows a progress in creating sustainability of projects results, and that actions have been taken to further enhance the sustainability of NeIC

projects. However, even though NeIC is committed to the realisation of benefit realisation, there is still room for improvement.

6.2 Governance, strategy, and action plans

The Nordic funding arrangements for NeIC set up back in 2012 will end in December 2022. Therefore, the NeIC Board has put forward an Expression of Interest to NordForsk for future funding of NeIC. The Expression of Interest is to be confirmed by the national research funding organisations in the Nordic region and Estonia.

In the Expression of Interest NeIC states that the organisation wishes to continue its coordinating role for joint Nordic activities within research e-infrastructure. From 2023 onwards, in addition NT-1, NeIC plans to focus on long-term collaborations with the biodiversity, earth system modelling and human sensitive data communities.[51]

NeIC asks for NOK 21.3 million annually from NordForsk (from 2023) for joint Nordic activities, in total 30% of the total funding of NeIC. In addition, NeIC propose that NordForsk continues to host the NeIC secretariat, including NeIC director and administrative coordinator, and administrative functions, in accordance with the current agreement with NeIC partners. The remaining of NeIC's budget, 70% of the total funding, is proposed to be covered by national membership fees and in-kind contributions from the partners in the NeIC activities:

- Annual membership fees of NOK 5 million from Denmark, Finland, Norway and Sweden each, NOK 1.1 million from Estonia and NOK 0.2 million from Iceland. Total contribution from the national funding agencies is NOK 21.3 million.
- In-kind contribution from the partners in the NeIC activities totalling NOK 28 million annually, conditional on the funding levels from the national funding agencies and NordForsk described above and continuation of the NeIC collaboration model.

The Nordic resources asked for by the NeIC's board is the same as during the period 2012-2022, approximately20 MNOK annually. A NeIC Board representative points out that the organisation's funding structure affects its organisational preparedness for future development negatively:

> *At the current model, the weakness is the funding structure. One third of NeIC funding comes from national funding agencies, and they are all a bit off sync regarding each other. Their funding commitment are different in different countries.*

[51] https://wiki.neic.no/w/ext/img_auth.php/5/5a/NeIC_Expression_of_Interest.pdf

NeIC has grown over time in terms of funding, projects, members, and complexity. NeIC seems to have expanded in directions and at a pace that key stakeholders have not kept up with. Key stakeholders argue that the financing of Nordic co-operation in e-infrastructure must be characterised by a long-term perspective but also a much clearer idea on NeIC's future role, strategy, and activities. This weakness is also highlighted in the self-assessment: "a common Nordic voice is missing in the boardroom discussions and that a wider diversity of perspectives could reinvigorate future strategy development. A related weakness at the Nordic system level is the lack of a common and inclusive dialogue space where Nordic strategies on research and research infrastructure can be discussed."[52]

From key stakeholder Interviews it is pointed out that "increased visibility and optimization of NeIC is necessary. Nordic Added Value must be reported more clearly. The activities must be managed more clearly by Nordic Added Value" and that "it's important to connect the strategic and operational level! It is missing today. But NeIC must continue to have a close connection with the Infra-providers". One solution presented is "a closer connection to NordForsk, part of NordForsk's future strategy. So NeIC can be part of NordForsk".

6.2.1 Our assessment

The commitment in terms of funding structure for NeIC varies throughout the Nordic countries. As NeIC has grown over time and expanded its activities, the evaluation clearly shows that its stakeholders have not kept up with the new directions of NeIC. The Nordic cooperation in e-infrastructure needs to be backed up by clear and shared commitments to NeIC regarding its strategy and activities.

Evaluation data indicates that NeIC is in need of a clear strategic direction and mandate from its key stakeholders, specifically the NordForsk Board and national research infrastructure funders (NRICC committee under NordForsk) to improve NeIC's preparedness for further development. For NeIC's potential to be fully realised, these stakeholders need to have a common understanding and position on NeIC.

Future investment in Nordic e-infrastructure cooperation must go hand in hand with efficient resource utilisation and well-considered strategic choices. Hence, there is a need for NordForsk, NRICC and the national e-infrastructure providers to decide on NeIC's future role and funding. In the forthcoming NordForsk strategy, NordForsk (potentially through NRICC) need to set an overall strategy and priority for NeIC. In this process, there is a need to have a dialogue with NeIC Board.

[52] NeIC self-assessment 2022

7 Lessons learned and recommendations

This Chapter discusses lessons and presents recommendations for NeIC and its stakeholders.

7.1 Conclusions

NeIC has developed well as a distributed organisation over the past decade within a rapid evolving and complex multi-layered ecosystem. NeIC has grown over time in terms of funding, projects, members, and complexity. NeIC has expanded its activities from services for high-energy physicists to sensitive data management, climate modelling, biodiversity, collaboration in high-performance computing, and harmonisation of policy and service provisioning in the Nordic and EU. NeIC operates a high-quality and sustainable Nordic Tier-1 service supporting the Large Hadron Collider (LHC) research programme. However, NeICs strategy is quite complex with several priorities. NeIC has expanded the project portfolio in directions and at a pace that key stakeholders have not kept up with. Organisational consolidation, strategic growth, and better integration with NordForsk and national key stakeholders is assessed to be critical focal points for the years to come, to achieve maximum NAV.

7.1.1 Governance and management

NeIC operates in a complex governance landscape with strategic and operational relations to several different actors on the national level, within the Nordic collaboration as well as growing ties to the rapid evolving European landscape for e-infrastructures and HPC. We also note recent and ongoing strategic and organisational changes on the national level re-configurating the core stakeholder community. Finding a suitable, recognizable, and strategic position in this evolving landscape is a key challenge for the coming years and will require a clear focus on NAV and a renewed dialogue on how that can be delivered. There is a need for NeIC to be more aligned with national strategies and priorities and deepen the understanding of the development on national and EU level to be able to find a common Nordic ground due to the accelerating development pace of e-infrastructure services internationally.

One central part of this dialogue is the NordForsk/NeIC interface. The governance and strategic relations with NordForsk are – and maybe always have been – not fully developed and commonly understood and aligned. A renewed alliance on strategic and operational level between NordForsk and NeIC is a key element going forward. Joint Nordic actions within eScience and e-infrastructure should continue to be looked upon in a holistic and integrated way to support prioritization and strategic focus.

NeIC needs to continue to pay attention to and learn how to best operate in the evolving landscape described about in terms of strategy and operational activities. A weakness in the present governance model of NeIC is the lack of a forum for the national e-infrastructure provider

organisations (NeIC Board), National research infrastructure funders (NRICC), NordForsk, and NeIC team where this type of challenges and strategies can be discussed. We see a need for such a common Nordic e-Forum to develop, and that can be organized or co-organized by or with NordForsk to strengthen the strategic coherence of NeIC.

There is a need for NordForsk and NRICC to decide on a "strategic integration" of NeIC into future NordForsk strategies. NeIC is a well-organised and professional organisation that has developed well since 2012. The long-term continuity in the project management and at director level is impressive and have been of essential for the successful development over the past decade. This effort should be highly recognized and praised. However, it is at the same time of growing importance that NeIC – on operational and strategic levels – dedicate attention to stepwise attract and foster the next generation of management and leadership to secure long-term continuity and renewal.

7.1.2 Portfolio and projects

NT-1 is a successful activity of NeIC. Since it is also cost-effective, we find that other alternatives might give less added value to the Nordic countries. There are also projects that are fruitful, in particular PUHURI and CodeRefinery. The other projects are relevant – and in alignment with stakeholder interests and user-needs, but there are some issues concerning the sustainability of project results and NAV. There is also an issue on the effects and impact of the whole portfolio and its mix. NeIC partake in many key projects on EU scale (EOSC, CERN, LUMI). Participation in future EU-projects should be carefully assessed and strategically selected only if there is a strong case for NAV.

The demand for a platform for Nordic collaboration within research e-infrastructure is anticipated to increase in the coming years and NeIC as a distributed organisation is well positioned to respond to this demand. However, a more strategic approach to developing a balanced project portfolio mix to maximize NAV should probably have fewer and bigger project for bigger impact and better sustainability. Potentials to create synergies with the overall NordForsk program portfolio should also be assessed to further increase NAV.

Results and benefits from the projects need to be better packaged and communicated to the Nordic research community. NeIC has recently put more effort into enhancing how projects realised benefits and into strategic communication, but our assessment is that the work can be developed and prioritized even further and focus more on NAV and the communication of outcomes and long-term impact.

7.1.3 Budget

The NeIC organisation should continue to be funded by and managed through NordForsk. The Nordic Tier-1 (NT-1) operates very successfully and should be continued as today. However, a larger part of the NeIC project portfolio should be identified through and funded with a more strategic approach, preferably by NordForsk to secure quality, relevance, and increased NAV as well as an increased strategic and synchronized involvement from key national stakeholders.

A renewed MoU between the funding agencies for a further period is needed to secure the long-term base funding of NeIC. In addition, there is a need for alignment of the national funding periods of NeIC.

The overall level of NeIC's Nordic resources seems appropriate. However, the mix between base funding and external project funding should be regularly monitored and kept on a healthy balance for maintaining an efficient and sustainable organisation that can balance between renewal and stability. If the proportion of external funding is allowed to grow too much, there is a risk that the needed strategic governance of NeIC will be hard to deliver.

7.1.4 Community

Over the past decade, NeIC has built a strong network, recognition, and reputation within its core community of national and international stakeholders and partners. This is a major achievement that creates a solid base for the future. Continued focus on outreach and communication is important to further broaden the knowledge about NeIC on the national level.

Future strategies should pay increasing attention to identifying and engaging in dialogue with potentially new user-communities and areas that can benefit from the future developments within e-infrastructures in the coming decade. Funding mechanisms needs to be in place for competence build, pilots, and preparatory actions to attract, develop and integrate new user groups.

7.2 Recommendations

7.2.1 Key overall recommendations

- Set up a Nordic e-Forum for the national e-infrastructure provider organisations (NeIC Board), National research infrastructure funders (NRICC), NordForsk and NeIC team where challenges and strategies can be discussed. The Forum should be organized or co-organized by or with NordForsk to strengthen strategic coherence of NeIC and NordForsk
- In the forthcoming NordForsk strategy, set an overall strategy and a clear priority for NeIC. In this process, NordForsk Board and NRICC should have a dialogue with the NeIC Board. NordForsk Board, NRICC and the national e-infrastructure providers (through NeIC Board) needs to jointly decide on NeIC's future role and funding

- Set up a renewed MoU between the funding agencies for a new period to secure the long-term base funding of NeIC and provide a strong foundation for continued and stepwise strategic developments and secured core functionalities

7.2.2 Specific recommendations to stakeholders

Recommendations to NordForsk Board:

- Continue to host and financially support NeIC, in particular NT-1 but also other projects
- Facilitate a process to identify and secure more strategy and portfolio integration and synergies between NordForsk and NeIC in close dialogue with the national stakeholders

Recommendations to NeIC Board:

- Simplify forthcoming strategies and plans and reduce complexity within the organisation and portfolio
- Develop a long-term plan to secure generational change in project management and leadership
- Pay increased attention on securing NAV in all the operations and communicating NAV to key stakeholders, both for NT1, projects and NeIC as an organisation
- Participate only in carefully assessed and strategically selected EU-projects where there is a strong NAV
- Pay increased attention on creating sustainability of projects results and communicate/create awareness of available services outside the NeIC network

Recommendations to NRICC (national research infrastructure funding organisations):

- Continue to financially support NeIC and work with NordForsk in developing an overall strategic framework and priorities for NeIC
- Seek to align the national funding periods in order to keep administrative burden at a low level for NeIC
- Support NeIC in communicating results and create awareness on benefits from NeIC activities and projects on the national level

8 Appendix A Interviews

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