The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

Evaluation Report for Administrative Unit

Administrative **Unit: Norwegian Computing Center (NR)**

Institution: **Norwegian Computing Center (NR)**

Evaluation Committee Institutes

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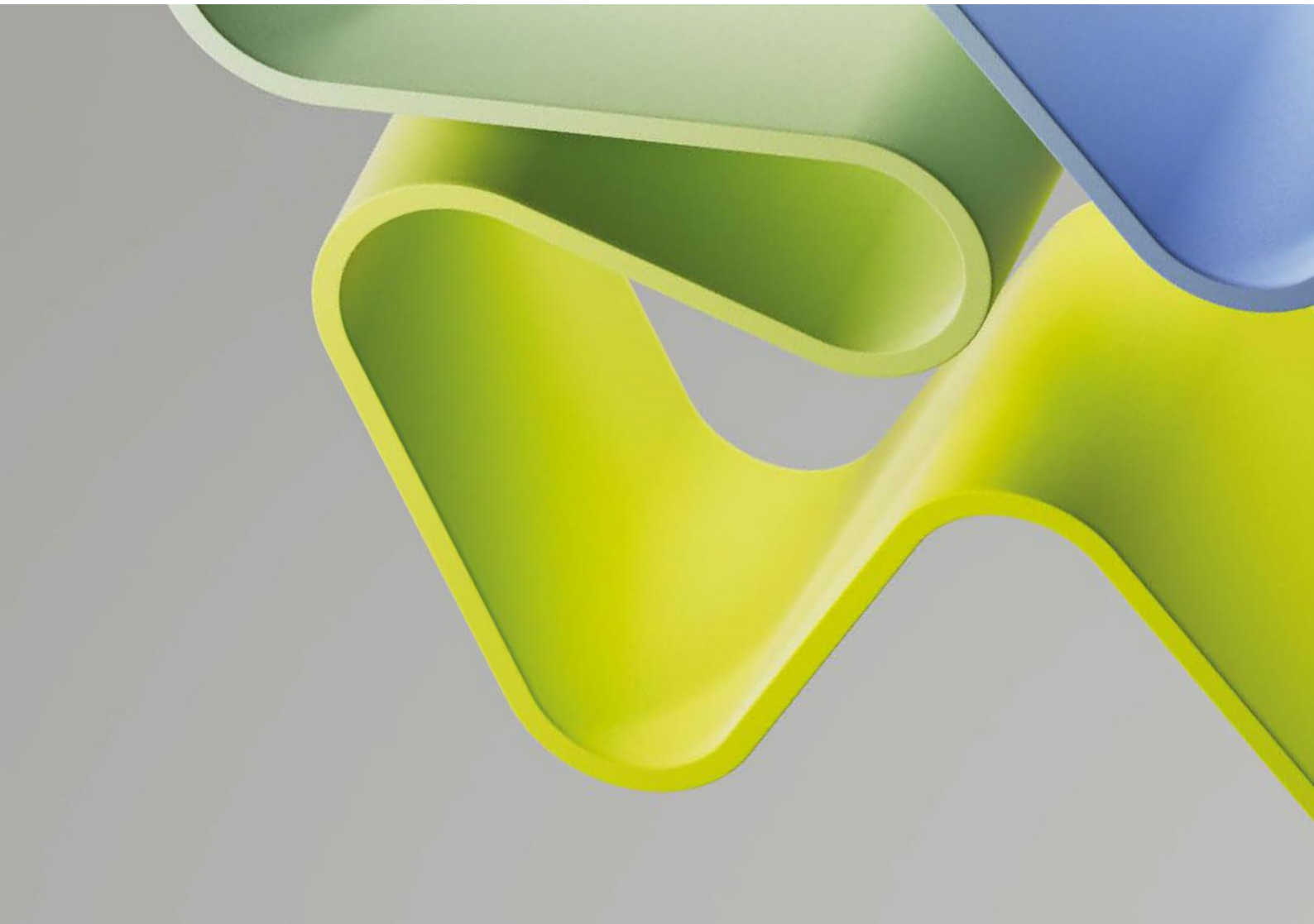

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Statement from Evaluation Committee Institutes

The members of this Evaluation Committee have evaluated the following administrative units at the research institutes within Mathematics, ICT and Technology 2023-2024 and have submitted a report for each administrative units:

- NORCE Energy and Technology, NORCE Norwegian Research Center (NORCE)
- SINTEF Community, SINTEF Community
- SINTEF Digital, SINTEF Digital
- SINTEF Industry, SINTEF Industry
- SINTEF Energy, SINTEF Energy
- SINTEF Ocean, SINTEF Ocean
- SINTEF Manufacturing, SINTEF Manufacturing
- Norwegian Computing Center (NR), Norwegian Computing Center (NR)
- Energy and Energy Technology (ENET), Institute for Energy Technology (IFE)
- Simula Research Laboratory (SIMULA), Simula Research Laboratory (SIMULA)
- Human and organisational factors (HOF), Institute for Energy Technology (IFE)

The conclusions and recommendations in this report are based on information from the administrative units (self-assessment), digital meetings with representatives from the administrative units, bibliometric analysis and personnel statistics from the Nordic Institute for Studies of Innovation, Research, and Education (NIFU) and Statistics Norway (SSB), and selected data from the National survey for academic staff in Norwegian higher education and the National student survey (NOKUT). The digital interviews took place in the autumn 2024.

The members of the Evaluation Committee are in collective agreement with the assessments, conclusions and recommendations presented in this report. None of the committee members has declared any conflict of interest.

The Evaluation Committee consisted of the following members:

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Description of the Administrative Unit

The Norwegian Computing Centre (NR) is a private research foundation. It is split into 4 Research Departments, each overseen by a Research Director. NR has 75 research staff, of which 4 are PhD students, 4 are Research Scientists, 52 are Senior Research Scientists, 7 are Chief Research Scientists, and 8 are Research Directors/Assistant Research Directors. The four Research Departments within NR are SAMBA, BAMJO, SAND and DART.

NR states that they address society's demand for knowledge in data processing and quantitative methods through performing R&D tasks with industry and public admin, conducting research projects with support from the RCN and other sources, cooperating with UiO, disseminating research findings and supporting the development of staff members. Their operations and strategy are reviewed and adjusted, ensuring that these outlines are secured in a balanced way. They develop and employ state-of-the-art methods to provide new insight from data in a number of fields, including climate, public health, Earth observation, petroleum and information security. Working closely with industry, their solutions are tailored for each client, making them different from universities, but they often draw from generic methodologies in their work.

NR states that they have made a huge impact on Norwegian society, especially given their modest size, with their services creating tangible value. They claim they can translate academic knowledge into practical applications for industry. During the coronavirus pandemic, NR worked with the national health authorities to predict disease transmission throughout Norway, and government regulations based on the analysis were adopted. NR enters and contributes to areas at their early stage, and often leaves once they are commercially mature. They are currently at the forefront of research in Explainable Artificial Intelligence which they foresee becoming essential as AI integrates into society. NR has established collaborations and partnerships with many different institutes, such as the Institute of Marine Research, which has spanned more than three decades. They also have a historical partnership with UiO, with the formalisation of a new collaboration agreement occurring in 2022. They also have academic ties to UiT, UiB and NTNU.

In their self-assessment report, NR highlight a number of strengths and opportunities that better position themselves for the future. They note their attractiveness as an employer, especially to young researchers due to their dynamic work and competitive salary. They also point out their degree of market flexibility – as a methodology institute that specialise in statistical modelling, they are easily able to adapt the files which they are working on whilst using the same researchers and competence. NR note the market growth in their expert disciplines, and they foresee themselves potentially shaping AI policies and guidelines as AI becomes more prevalent. In terms of weaknesses and threats, they identify their limited external visibility due to challenges in communicating their research contributions and limited funding. They also highlight intense competition for top researchers and scientists leading to difficulties in staff retention. Finally, as oil and gas production are NR's largest market, volatilities in the petroleum market make NR particularly susceptible.

Overall Assessment

Norsk Regnesentral's (NR) core mission is to conduct applied research that adds clear value and has a high impact on Norwegian businesses and society. It has been very successful in meeting its goals over a long period. NR is organised into four departments of rather different sizes that specialise in distinct research domains, supported by a small administrative staff. Its work involves close collaboration with clients such as companies and public bodies and generally requires statistical analysis of their data or the development of methods to do so. Around one-third of NR's funding arises from contracts from companies, sometimes as part of long-term framework agreements, and some results have been of high commercial and societal value. NR also receives basic funding from the Norwegian Research Council (NRC), grants from Norwegian and European research organisations, and public bodies such as ministries. It plays a key role in several NRC-funded centres for research-based innovation. It has links with other research institutes and university departments in Norway and elsewhere, most prominently at the University of Oslo. Thus, it has a good diversity of funding streams. Questions arising from contracts and grants often stimulate the development of methodology that is typically published in specialised journals, though some appear in more general outlets. Unlike methodology, specific results, some computer code and customer data may be commercially sensitive and are typically available only to clients. In order to avoid conflicts of interest, NR does not itself create spin-off companies, but it may collaborate with clients and its former staff in doing so; some of the resulting start-ups have been quite successful. Recent developments in machine learning and artificial intelligence (AI) are having increasing societal impact, and NR is involved both in their use for data analysis and their implications in areas such as digital security and inclusion. NR is aware of the resulting challenges and has strategies to meet them.

NR's research adds high value for its customers and allows Norwegian and, to a lesser extent, international clients to profit from new data streams and to face new challenges, such as those posed by climate change and societal and technological developments. Several of the individual group assessments comment that higher ambition in terms of publication would be welcomed, as NR's record relative to other institutes is mixed. As mentioned above, much of NR's research is applied, which is natural in view of its core mission and main sources of funding, and although some of its basic methodological research has high impact, it is less extensive. Open access to code and publications has risen and is now at a good level, but data is generally owned by clients and may be commercially sensitive, so it is often unavailable. Research integrity appears to be very high.

The workforce at NR is highly skilled and has grown appreciably in recent years. Employees typically join direct from a PhD and then develop their careers within NR, by broadening their experience of different application areas and widening their skill sets and knowledge. The NR strategy of building long-term collaborations with (generally) Norwegian clients mitigates against the hiring of workers without a long-term commitment to Norway and may reduce diversity to some extent, but equality of treatment is part of the organisational DNA. The need for consistent contacts with clients and difficulties with finding appropriate funding militate against allowing research leaves away from NR. Relative to similar institutes there are few temporary employees, with a handful of PhD students and some summer interns, the latter typically MSc students.

NR has a long history of valuable contributions to Norwegian businesses and research, and a generally clear strategy towards continuing this tradition. Examples include its work on accurate geological modelling of oil and gas deposits for use by actors in the energy sector, on image analysis for forestry and wildlife applications, on pests in salmon fisheries, on

financial risk assessment for banking applications and on the effects of climate change on insurance risk. A watching brief is needed to ensure that all NR departments can pivot to new areas if current funding streams dry up.

During the Covid-19 pandemic certain NR members played a key role in the epidemiological modelling needed to understand the spread of the virus in Norway and required for policy formulation, e.g., for vaccination strategies. Although fortunately a very rare event, this showed how NR skills and resources could rapidly be deployed for the public good and raised its profile. Apart from the creation of jobs in start-ups and contributions to the growth and development of its clients, longer-term contributions to society include contributions on digital inclusion, security and transformation, some of which are embodied in draft legislation, and prominent recent developments in interpretable AI. Strenuous efforts are made to maintain contact with the public through popular science articles, presence at suitable public events and social media.

Overall, and despite some points that merit consideration, NR has a unique market position, a broad base of funding streams, and a good strategy for future growth.

The Terms of Reference for the evaluation highlighted two specific points for the evaluation committee to pay specific attention which they have considered as part of their evaluation:

1. Norsk Regnesentral has a long and proud tradition and responsibility as the foremost national competency centre for applied statistical modelling, including its convergence with machine learning and artificial intelligence.
2. Norsk Regnesentral’s primary mission is to conduct valuable and highly relevant applied research in close partnership with Norwegian industry and society. Collaborations with Norsk Regnesentral should result in enhanced operational activities for private and public clients, manifesting in higher revenue, increased efficiency, or minimised losses, among other benefits. Conversely, applied challenges should provide feedback and stimulus for our basic methodological research, which, in turn, is vital for future applied use.

The Terms of Reference for the administrative unit is attached to the report.

Recommendations

General recommendations

1) Consider how basic methodological research can be supported and how its fruits can be published more prominently.
2) Consider how to increase the number of temporary and/or junior research staff, especially PhD students and post-docs.
3) Consider what funding will replace SFI income when the latter winds down.
4) Consider how to leverage NR's high reputation to increase access to EU and other international funding, particularly regarding basic methodological research.
5) Ensure that code and illustrative datasets are systematically made available via appropriate platforms.
6) Consider how enhancing funding and opportunities for research mobility might assist with internationalisation, upskilling of personnel and creating new collaborations with important external actors.

7) Consider an initiative to include quantum computation in your strategy. This could be in the form of, e.g., quantum simulation, and need not involve investment in a quantum computing facility. This could be fruitful in acquiring EU funding.

Recommendations to specific research departments

1) BAMJO should elaborate a strategy for keeping its expertise up to date.
2) BAMJO should have more ambitious goals, e.g., more often leading when authoring high-quality publications or setting up international project consortia.
3) DART should aim to involve PhD students in projects more systematically.
4) SAMBA should guard against overdispersion of its domains of competence.
5) SAND should broaden its academic collaborations to create more opportunities for high-level publishable research.
6) SAND should consider how to broaden its income streams, especially in regard to the green transition.

1. Strategy, Resources, and Organisation of Research

Norsk Regnesentral (NR, the Norwegian Computing Centre) was founded in 1952 and has a long history of applied research in statistical data analysis, in machine learning and pattern recognition, and information and communication technologies. Its stated primary mission is “to conduct valuable and highly relevant applied research in close partnership with Norwegian 'industry and society”, and it achieves this with high success. NR performs contract research for companies and public sector bodies and obtains grant funding on a competitive basis from national bodies such as Norwegian ministries and the Research Council of Norway (RCN) and from international bodies including the European Union.

NR is organised into four research departments (of sizes 15, 20, 22, 31 persons) giving a total of around 90 staff, plus an administrative support group of size 15. The research departments work on largely disjoint areas, though two or more may contribute to projects that require more than one type of expertise. Research staff rarely change between departments.

Much of the research is performed as individual contracts but often as part of long-term collaborations that may last over decades and thus bring durable benefits for clients and partners. All the research is collaborative in nature, as the research departments aim to use their clients' data to add value to customer activities and to suggest new possibilities to them. Novel methodology arising from the research is generally published, typically in the more applied literature, but data is generally owned by clients and typically remains unpublished. To avoid conflicts of interest with its clients, NR generally avoids the creation of companies stemming from its research output but may help its partners or its own researchers in doing so; some of the resulting spin-offs have been rather successful.

1.1 Research Strategy

NR's stated goals are:

1. performing research and development for industry, commerce, and public administration;
2. initiating and conducting research projects with its own resources, support from the RCN, or other sources of funding;

3. cooperating with the University of Oslo (UiO) and other research institutions to use equipment and scientific resources;
4. disseminating national and international research findings to Norwegian users; and
5. supporting the professional development of staff members and preparing them for contributions outside the foundation.

All these goals are met, though some more obviously so than others; in particular, questions arise about aspects of goals 2 and 5, to which we return at the end of this section.

The strategy and outreach policies were unavailable to the committee, which was presented instead with eight "qualitative ambitions" in the self-assessment document, of which numbers 1-4 and 7 directly relate to research strategy, and the others relate to NR's finances and growth, recruitment and personnel practices and internal organisation. We now comment briefly on them.

Ambitions 1 and 2 concern NR's desire to be seen as a leading contract research organisation and research partner for private and public contract research and for grants. These seem largely to be met, though with caveats concerning `direct commissions' across the entirety of NR' (some departments are more successful than others) and `project leader' in research projects (the latter seems not to be the case with EU projects, perhaps a wise decision in light of their administrative burden, but potentially limiting of possibilities for international engagement).

Ambition 3 relates to the research environment and publication rate in relation to comparable institutes. NR is certainly seen internationally as generating strong applied research, but its publications in core methodology are more limited and are not uniformly spread across departments. It was stated at the interview that around three-quarters of NR publications are in `methodology-based' journals and the 'remainder in `field-specific' journals, but it is difficult to reconcile this statement with the listing on the NR website. Improvements to methods in specific domains with high added value for end-users are entirely in line with NR's strategy, but its interpretation of the phrase ‘basic methodological research' may be moot. Although its individual research groups have international comparators, NR has a unique combination of research activities that make direct comparisons difficult, though certain other broadly comparable institutes are more successful in terms of quantity and impact of basic research publications.

Ambition 4 relates to the communication of its science to the public. NR members engage with the Norwegian population on multiple fronts and on a range of topics within its ambit, so this ambition seems to be met well.

Ambition 7 concerns collaboration with UiO and other research institutions in order to produce `optimal, internationally recognised research'. Although it is unclear what `optimal' might mean in this context, NR has strong and long-standing research links on a range of topics with UiO and several other Norwegian universities, which have led to impactful publications. There are similar links with European institutions (e.g., Lancaster, Aberdeen, QMUL, HITS, ESA). High performance computing is provided by UiO and other local providers.

Although not specific research goals, we briefly discuss the remaining three "ambitions". Ambition 5 concerns financial viability and the social mission of NR, and seems to be satisfied, as attested by its growth and strong market position. Ambition 6 concerns staff recruitment and development. Although NR certainly has a strong profile, it is hard to assess whether it attracts the best candidates in its disciplines; it is an attractive employer with a stable workforce but the limited time available for `blue skies' research might be off-putting to

some very strong candidates or lead them to move to more academic environments. Recruitment of international candidates appears limited, as is the proportion of junior positions (especially in comparison to comparable institutes). Staff development is well-implemented and opportunities to specialise in the development of specific applications are welcomed. Ambition 8 concerns support for research and appears to be well met.

Collaboration is central to the research strategy of NR, whose primary goal is to use customer data to add value for clients via applied statistical modelling, machine learning and data science, and certain areas of informatics. This entails collaboration externally with clients to understand their needs and to ensure that these are met, and internally within departments at NR, both to benefit from complementarity of skills and knowledge and to develop the profiles and portfolios of junior researchers. The overall success of NR's strategy, and the quality and productivity of its work, is attested by its growth in financial turnover and in staff numbers, albeit with some heterogeneity among the four research departments. Within Europe it has a high reputation for excellent applied science, and it has made major contributions to Norwegian society and the Norwegian economy over a long period. This includes innovation that is valuable to existing clients and the creation of successful spin-off companies, usually linked to clients. For the future, a strategic initiative to enter the quantum era could be beneficial. This would not have to mean investing in quantum computers but could be realised via simulated quantum computation or via collaboration with suitable partners. This could be fruitful in acquiring EU funding.

The stability of its research staff shows that NR provides an attractive environment within which its members can flourish, but it seems crucial to find ways to mitigate the risk that this stability could lead to difficulties in facing new research challenges, adopting emerging techniques or branching out into novel areas. This risk may be offset by close contacts with local university departments, including joint appointments, but compounded by the lack of possibilities for research leave. Travel to conferences is supported and will result in a higher international profile for NR and its research, but it does not replace longer-term visits to leading institutions abroad.

NR hope that applied work that directly benefits clients, for example in terms of improved revenue, efficiency savings and reduced losses, will also stimulate its researchers to perform basic methodological research that can improve later applied work in a virtuous feedback loop. Although NR publishes the bulk of its applied results, including some code, with around 70% of its articles now open access, several of the individual department reports comment that higher ambition in publication, both in terms of quantity and quality, would be desirable. As mentioned above, NR contributions to fundamental methodology appear to be limited owing to the constrained time available to NR researchers for work not tied directly to clients. This relates to the goals listed at the start of this section; it seems that goal 1 has a much higher priority than goal 2, though the latter could lead both to more basic research and perhaps to publications that could help research staff to raise their external profiles, if they wish to do so, in line with goal 5. This being said, a track record of high-level publication is important for any staff who wish to take an academic path after time at NR, and funds are put aside for this.

The rise of AI will fundamentally reshape society. In particular it places a lower bound on the added value that a human researcher should provide when analysing data, and it should also lead to improvements in productivity that could result a loss of markets for NR. The NR focus on high added value due to close collaboration with clients can be expected to mitigate such losses, however, and may even add markets and clients. NR is strongly involved in this transition, particularly in regard to digital security, Norwegian AI centres, trustworthy AI and reducing AI energy consumption.

Recommendations to the administrative unit.

- Consider how basic methodological research can be better supported at NR, and how its fruits can be published in top-level journals and other outlets.
- Consider how to increase the number of temporary research staff.
- Consider an initiative to include quantum computation in your strategy.

1.2 Organisation of Research

NR is organised into four research departments (BAMJO, DART, SAMBA and SAND) totalling around 90 researchers and supported by 15 administrative staff (the numbers are taken from the NR website in October 2024). In line with the general nomenclature of the evaluation, we call these departments or groups interchangeably below. Almost all the research staff have permanent positions, with temporary staff restricted to a few PhD students and some MSc students engaged in summer projects.

The research groups are specialised in largely disjoint research domains. BAMJO (20 researchers) focuses its activities on image analysis and machine learning for earth observation, mainly funded by public bodies such as the RCN and the European Space Agency (ESA). DART (15 researchers) conducts research in digital security, digital inclusion and digital transformation, funded by industry clients, the public sector, and the RCN and EU. SAMBA (31 researchers) conducts research in four areas: finance, insurance and commodity markets; climate and the environment; ocean and health; and technology and industry. Its funding is from a wide range of sources. SAND (22 researchers) works on large-scale modelling of geological structures, mostly relevant to, and funded by, the Norwegian petroleum industry. This organisation into groups with distinct areas of expertise seems to be well-aligned with the ambitions of the research unit.

The overall strategy for research and recruitment is consistent with and furthers the goals of the unit. As mentioned above, the activity domains of the four research groups seem to be essentially disjoint, so careers develop within rather than between the different groups, though certain research projects may involve contributions from more than one group. Owing to a need for continuity of contacts with clients and the generally Norwegian focus of the research projects, opportunities for mobility and the level of internationalisation seem limited relative to other, especially academic, environments.

Recruitment of strong juniors mostly takes place after their PhD degrees, some of which may have been performed jointly with NR, but efforts are made also to reach out to strong MSc students via the provision of summer projects integrated into the teams, within which they are mentored, and via prizes for excellence in MSc studies. There seem to be few, if any, post-docs on temporary contracts. Considering NR's goals and the setting in which it operates, the training and mentoring efforts seem to be good.

Recommendations to the administrative unit.

- See the individual group assessments.

1.3 Research Funding

Overall research funding is around 140 and 152 MNOK in 2023 and 2024, respectively, substantially greater than the average 108 MNOK for 2018-2022 shown in the self-assessment document, and equivalent to around 1.5 MNOK per year per researcher. Clearly NR supports its members in applying for external funding, with considerable success, particularly at the national level, with NR involved in six of the national SFIs and numerous

other projects. Contracts from Norwegian industry account for around 50% of the total research income. International grants (EU and industry) account for around 7.5% of the total. Grant income and particularly its growth are commensurate with, and attest to, the high level of applied research at NR.

Recommendations to the administrative unit.

- Consider what funding will replace SFI income when the current sums wind down.
- Consider how to leverage NR's high reputation to increase access to EU and other international funding, particularly with regard to basic methodological research.

1.4 Research Infrastructures

The main activity of NR is data analysis, which requires skills and experience, access to data and adequate computing power. Data is generally held by partners and provided to NR for specific projects. Code arising from methodological research is made available via GitHub and via journal websites. Sensitive personal data must be held on dedicated servers.

Computing facilities at NR are not mentioned as a constraint in group reports, which suggests that they are felt to be adequate. High performance computing infrastructure is available from outside bodies (UiO, Sigma2) and is used where needed, but use of ESFRI has been limited to one life sciences project. The FAIR principles are generally adhered to in the rare cases where data is owned by NR.

NR is involved with two national infrastructures (the Norwegian Historical Population Register and the SeeBee Research Infrastructure) of social and physical importance; it is project owner of the first, which involves 180 volunteers and is becoming a major open research resource.

Recommendations to administrative unit.

- Ensure that code and datasets for novel methods are systematically made available via appropriate platforms.

1.5 National and international collaboration

NR's goal is to act as a centralised methodological institute in statistics, data analysis and related areas, and inter-disciplinary collaboration is central to this, with clients from, first, the private and public sectors, second, research institutions needing NR expertise, and third, academic institutions.

The first involve single contracts, often as part of a series of long-term collaborations, sometimes within framework agreements.

The second are typically enduring partnerships with bodies such as the Institute of Marine Research or the Norwegian Water Resources and Energy Directorate and leveraging NR expertise in the national interest.

The third involves several departments at UiO, but also UiT (Visual Intelligence), UiB (Geopard) and NTNU (AI), including some joint appointments, and joint work with STI centres, especially as leader of BigInsight. There are also links to national research consortia and to public-facing science.

International collaborations are mainly with university departments (plus the International Council for the Exploration of the Sea and the European Space Agency) and have allowed NR activities to develop outside Norway.

Overall, the level and depth of collaboration are high, it is essential to the continuing success of NR, and major efforts are made to sustain successful partnerships and to recruit new ones.

Recommendations to administrative unit.

- Some groups should broaden the range of their academic collaborations to create more opportunities for high-level publishable research.
- Aim for further EU-based and other international collaborations.

1.6 Research staff

The self-assessment document shows the distribution of senior and junior positions and the gender balance; the latter is good in relation to the sector but is uneven between departments (according to the website the ratios of women/all appear to be BAMJO, 5/20; DART, 2/15; SAMBA, 12/31; SAND, 5/22). The age pyramid is not provided, but according to Table 2.1 of the Register of Research Personnel, there were six researchers aged 62 or above in 2021, and the mean age is around 43 years. The only temporary researchers are four PhD students, which is low both in relation to academic departments (where one would also find post-docs) and, more relevantly, in relation to similar institutes, especially in areas such as machine learning and AI that are attractive to students and developing very fast. The resulting stability of staff is positive for NR, but since sabbaticals outside NR are unavailable, continued effort is needed to remain abreast of developments in fast-moving areas, for example, by travel to appropriate conferences.

There seems to be no specific succession planning other than the recruitment of (typically) recent MSc and PhD graduates, who then typically step into more senior roles within NR as their competencies and interests develop. The highly team-based approach at NR means that knowledge and skills are shared, which increases the robustness of the organisation. Losses to partner institutions such as UiO can be seen as a net plus, as they strengthen existing links between research partners.

Longer-term research leave is unavailable owing to difficulties with funding it and the need for continuity in contract research, but on average around 1.5 days/week is "used for marketing, administration and scientific development", though with considerable variation between individuals. Intellectual mobility and professional development are ensured by working in teams with differing skills and research problems.

Recommendations to the administrative unit

- Explore increasing the number of temporary and/or junior staff.
- Consider how enhancing funding and opportunities for research mobility might assist with upskilling of personnel and creating new collaborations with external actors.

1.7 Open Science

NR's approach to open science is improving rapidly, as articles and code are increasingly freely available. In 2022 around 70% of accepted peer-reviewed manuscripts were available by green or gold open access (OA), generally under CC licenses. In 2013 just 4.5% of work was OA, demonstrating a marked improvement. Code is increasingly published on GitHub, with anonymised case studies, as original data provided by commercial partners may be subject to confidentiality agreements. Privately funded research is made available using NR's base funding, and publicly funded research is made OA using grant money.

At a more popular level NR engages with the public via traditional and social media, and via a citizen science project building a historical population register with 180 volunteers and in the research group on digital inclusion.

Open science and research ethics training is provided to new employees. NR has a data protection officer and has employees with experience in issues related to the ethical use of

medical data. One of the research directors plays OA roles at higher advisory levels for Norwegian science.

In the main NR does not possess data, which is generally diffused by the providers of data for specific projects (health data, marine data, etc.), each of which has its own OA policies.

2. Research production, quality and integrity

The research of NR involves the application and development of existing methods in statistics, modelling, machine learning, image analysis and artificial intelligence and related areas to data analysis problems brought by their partners, plus methodological research where necessary and feasible. The research departments work across a very wide spectrum of applications, from areas of traditional importance to Norway (e.g., fisheries, marine science, geoscience, energy and the environment) through medical and environmental imaging, health, finance and insurance, to topics related to the digital future (e.g., online access, inclusion and security). The activities of the four research departments were summarised briefly in Section 1.2 and are given in more detail below.

Around 50% of the research funding relates to research contracts with industrial or public partners, and the publications resulting from this work are typically in more applied journals. An increasing proportion of NR publications are openly available (46.2% in 2022). According to the NIFU bibliographic analysis provided to the evaluation committee, NR's publication level is low (65 publications in 2022) compared to most of the institute sector, the mean normalised citation score is the lowest in the sector (85) and the number of co-publications with the listed `top' international institutions is small (7.4%). Such comparisons should not be taken at face value because of variation in citation patterns in different domains, but several of the individual group reports suggest that NR should seek higher-quality publications, in which their contributions more clearly evidenced, to increase the impact and visibility of the best work performed in the unit. This might entail building new or strengthening existing partnerships with academic institutions and/or raising suitable funding to make more space for `blue skies' thinking alongside contract work.

NR adheres to established privacy practices for any collaborations involving personal data and has strong internal expertise in data ethics. Ethical dilemmas that sometimes arise due to problematic clients or research topics are discussed openly. Potential ethical violations would be referred to a committee that deals with such issues for the entire institute sector. The committee has only had to judge one case so far (and not in NR), so such problems appear to be very rare.

2.1 Research quality and integrity

Research group Image analysis, Machine Learning and Earth observations BAMJO overall assessment

BAMJO has long-standing expertise in the application of machine learning methods in applied image analysis. The group attracts substantial third-party funding from a range of sources and contributes to internationally relevant and visible research on numerous applications of societal importance, including in international networks such as the European Space Agency's (ESA) climate change initiative on snow coverage (Snow_cci). Its members have contributed to numerous publications in prominent international journals, but often not in leading positions. As a non-university organisation, NR depends on hiring staff educated by others, in a highly competitive field, so university collaborations are crucial to attract well-trained graduates who can continue its success, and the group could aim to co-supervise more graduate students. Moreover, BAMJO needs strategies for keeping the expertise within

the group up to date, as it operates in a rapidly developing area. The objectives laid out in the self-assessment are rather conservative in the sense that many of them are (partly) fulfilled already. It seems highly probable that BAMJO will continue to fulfil its goals, but more visionary and ambitious statements would be welcome. For example, BAMJO could strive to be more often in a leading position, both when authoring high-quality publications or setting up international project consortia.

Research group Department of Applied Research in ICT (DART) overall assessment

DART works in the areas of digital security, digital inclusion and digital transformation, and is a strong research environment targeting these important societal issues. The group's strengths include very solid funding, with a diversified project portfolio showing the ability to attract funding from industry clients, commissioned public sector research, Research Council of Norway and the EU. DART works closely with client organisations and problem owners and shows high research and innovation performance relative to similar research environments. The strong problem-solving orientation is mirrored in the publication strategy, which mostly targets level 1 publications. This is a fair trade-off, but higher ambition in terms of publications would be desirable. The group hosts a few PhD students and is engaged in teaching, master student supervision and summer internships. A strategy to involve PhD students more systematically in projects is advised. The group contributes highly to societal value, works closely with clients, and engages in many user-driven projects. Its international standing is good.

Research group Statistical Analysis and Machine Learning for user motivated applications (SAMBA) overall assessment

SAMBA performs statistical data analysis in four main domains: climate and the environment; finance, insurance and commodity markets; ocean and health; and technology and industry. Much of the work is performed for specific Norwegian clients and this leads to IP issues that can hinder publication of the results themselves, though novel statistical approaches and new methods that arise from specific projects are typically published in specialised journals. There are also high-impact publications in prominent general journals, but the overall emphasis is on customer-tailored work of commercial value to clients, in line with NR strategy. In these terms and in terms of societal impact the research group achieves and even exceeds its goals, as seen from its secure financial position, repeat contracts from long-term clients, and steady growth in recent years. It is the largest group at NR and is known internationally for strong applied statistical work.

Apart from the publication issues, a weakness of the group relative to others in the institute sector is its small proportion of junior staff. Other points of concern are limited internationalisation, both in terms of funding and in terms of possibilities for research visits, and the need to guard against overdispersion of domains of competence.

Research group Statistical Analysis of Natural Resource Data (SAND) overall assessment

SAND provides large-scale modelling and software solutions for partners in the Norwegian petroleum industry, which provide substantial funding for the group's research. The research centres on mathematical and statistical modelling of geological properties of oil and gas deposits and is embodied in software that is used by national and international companies and thus has an important commercial impact in a domain of major importance to Norway. By contrast scientific output in terms of publications has become limited due to decreased funding for non-contract research. The group is aware of this and has a strategy to improve their research profile by deepening academic links and their visibility in the broader scientific

community, possibly by increased collaboration in terms of MSc and PhD theses. This may also help to diversify research areas well before oil and gas extraction start to be phased out. Even if the green transition will take time, the group seems to be taking a piecemeal approach rather than formulating an explicit strategy for it.

3. Diversity and equality

In 2021 the NR had 78 researchers with PhD or MSc degrees, of whom 24 (31%) were female, 73% had PhD degrees (79% for women), 10% had foreign PhD degrees, and 6% were aged 60 or over. This represents growth from 58 researchers (of whom 21, or 36%, were female) in 2013. In 2013 62% of the researchers had PhDs.

The proportion of female researchers has remained broadly stable since 2013 (bearing in mind the relatively small numbers involved) and somewhat higher than in Norwegian mathematics, ICT and technology generally (25%, according to the personnel document).

The numbers with foreign PhDs have remained stable since 2013.

The policies and practices described in the self-assessment appear adequate.

Diversity is understood in broad terms that include age and educational background in addition to gender and identity and is seen as satisfactory overall. The likelihood of a long-term commitment to Norway is considered when hiring, and this seems natural in view of NR's aspirations for durable relationships with clients.

4. Relevance to institutional and sectorial purposes

This is a strong element of NR's performance and portfolio.

NR performs contract research for a wide range of institutions and companies and thus plays an important, mostly indirect, role in supporting commercial innovation underpinned by applied research; the role is indirect because of NR's desire to avoid conflicts of interest that might arise if it led commercialisation itself. This approach has led to numerous successful collaborations with industrial partners (e.g., in the analysis of seismic data, medical imaging, dynamic pricing, and energy demand forecasting).

Despite not being a higher education establishment, NR contributes to the training of MSc and PhD students through the provision of summer projects and PhD topics. Some of these result in later employment of the students by NR.

NR makes highly relevant contributions to policy and societal development (particularly to digital access and related topics, but also to public health during the recent pandemic) and to sustainability (particularly environmental studies, consequences of climate change, etc.) and to implanting research in industrial settings via contract research (also in supporting the development of commercial activities). Research dissemination via the media is also a main activity.

5. Relevance to society

NR makes substantial and impressive contributions to Norwegian society through its application-driven research, data-based modelling, informatics and data analysis, and through the resulting informed decision-making. The case studies illustrate diverse impacts of NR's activities: that on Covid-19 shows the capacity of NR to rapidly refocus existing expertise on a novel short-term crisis, whereas the other three illustrate the benefits of

longer-term research and development. Certain projects result in major reports of broad public interest that feed directly into policy and legislation, and others have important impacts in terms of health (e.g., pandemic policy, medical imaging), national financial and economic stability (e.g., climate and insurance risk), environmental protection (e.g., coastal mapping, earth observation) or key industries (e.g., fisheries, forestry or energy). The impact includes industrial collaborations involving the commercialisation of new methods.

The research contributions are mostly applied, apparently leading to relatively few publications in major methods journals. The emphasis in some cases is on porting existing techniques to novel areas, rather than on inventing new general methodology; while understandable in a busy environment this might be seen as disappointing in view of the `basic methodological research' mentioned in the terms of reference. Some of the contract research results in confidential software and reports for clients and is unpublished, but the bulk of the methods developed and related code are openly available in some form.

NR's contribution to higher education (not mentioned in the self-assessment document) appears more limited. The number of PhD and MSc students involved in NR's work seems to be rather small relative to its size, though five NR researchers have 20% positions at universities and seven university staff have part-time roles at NR, thus allowing potential contributions to higher education through application-based training of individual students and courses. NR also sponsors MSc prizes at UiO and NTNU, leading to potential for recruitment of strong students.

The activities of NR are overall well-aligned with the objectives of the Norwegian long-term plan (competitiveness, sustainability, accessibility) and with its thematic priorities (oceans, health, the environment, enabling technologies, societal security, trust). Moreover, much of NR's research is directly related to the relevant UN Sustainable Development Goals.

5.1 Impact cases

Comments on impact case 1: COVID-19 modelling

NR researchers played a leading role in shaping the Norwegian public health response to the COVID-19 pandemic. Four NR researchers were involved in this work, which was based on a 2019 PhD thesis that discussed how the epidemiology of influenza spread in Bangladesh could be understood using mobile phone data in a stochastic metapopulation model. Components of the COVID-19 work included estimation of the R number, prediction of hospitalisations and scenario analyses, and it played a role in the health-economical evaluation of potential interventions and underpinned political decisions and public communication. More than 200 reports were produced during the pandemic, often to tight deadlines, with other reports needed to understand the likely effects of policy responses (e.g., prioritisation of age groups for vaccination). The work made severe computational demands and led to numerous methodological innovations made to produce timely output and to address specific issues of societal relevance during the pandemic years. Some of this work has since been published in the peer-reviewed scientific literature.

Although atypical of its work, this outstandingly strong impact case illustrates how NR is able to react rapidly to a major societal challenge when necessary. The COVID-19 pandemic made unprecedented demands on epidemiological modellers worldwide and led to much innovative methodological work, and it was fortunate for Norway that NR had suitable expertise immediately at hand. Scientific modelling fed immediately into political decision-making, and NR played a crucial role in this. Key more general issues are the collection of reliable data for the monitoring of potential future epidemics, the maintenance of expertise

after the immediate need has apparently vanished, and better communication of uncertainty to stakeholders.

Comments on impact case 2: Geophysical inversion to geology

Seismic data are crucial in mapping hydrocarbon deposits and in assessing their viability. This impact case involves the use of Bayesian inverse mapping, based on Gaussian distributions informed by geophysical constraints, to rank possible subspace models in terms of their agreement with seismic data. The work was begun over a decade ago and has involved around a dozen members of SAND, with contributions from workers at outside companies (Equinor, AkerBP). The scientific basis for the approach has been published in the open literature and presented at industry conferences. It has been embodied in commercial software that is used by a consortium of eight companies and is available by licence worldwide.

This impact case is highly relevant to the hydrocarbon industry, particularly in Norway but also more broadly. The stated impact is on the software level, and the reader is left to guess the gain to the consortium is in terms of saved effort, economic benefits and the like. The strength of the impact is hard to assess (also with respect to unique benefits relative to other commercial and consultancy services mentioned in the document), though continued funding of the work suggests that clients see it as economically valuable.

Comments on impact case 3: Transformation of image analysis by deep learning

Over the past decade deep learning algorithms (deep neural networks, convolutional neural networks, etc.) have transformed computer vision and image analysis. NR expertise has been developed through experience with substantial applications to problems in handwriting recognition, wildlife and forestry, medical imaging, cultural heritage remains and marine science. Around a dozen NR researchers have been involved in the work, which has high impact in certain applications and has industrial applications (e.g., for medical devices).

This is a strong case backed up by a variety of publications in a wide range of journals and other outlets, some of which suggest a need for further improvements in classification accuracy. The group has made important advances in the application of ML methods to pattern recognition, successfully developed collaborations with a wide range of stakeholders in academia, industry and the public, and its advances have led to the creation of the SFI Visual Intelligence, which can be expected to lead to further strong results.

Comments on impact case 4: Digital inclusion

Digital inclusion refers to the removal of barriers to users who may be unable to access or use modern technologies for health, social, economic or other reasons. More than 50 projects have been conducted since 2012 involving a wide range of stakeholders and user groups, leading to the identification of different types of barriers to inclusion, development of methods and best practices for lowering such barriers, the design of accessible services and the establishment of related standards, and examination of the implications of access or its converse. Nine NR personnel have contributed to this work, which has been funded by governmental bodies and has led to the presentation of various reports to them (e.g., on e-voting, on universal design, digital inclusion in the workplace, and healthcare) and wide engagement with the public. Some of the impact is seen in the formulation of policy and in the drafting of legislation.

This is a strong case on a topic which is vital for the future health of democracies, and which clearly involves serious and long-standing efforts to engage with external stakeholders, including state institutions and the public at large. The impact seems to be substantial and is evidenced by large reports (in Norwegian).

Methods and limitations

Methods

The evaluation is based on documentary evidence and online interviews with the representatives of Administrative Unit.

- Evaluation Protocol that guided the process
- Terms of Reference
- Administrative Unit's self-assessment report
- Administrative Unit's impact cases
- Administrative Unit's research HEI's evaluation reports
- Bibliometric data
- Personnel and funding data
- Data from Norwegian student and teacher surveys (only for HEI's)

After the documentary review, the Committee held a meeting and discussed an initial assessment against the assessment criteria and defined questions for the interview with the Administrative Unit. The Committee shared the interview questions with the Administrative Unit at least two weeks before the interview.

Following the documentary review, the Committee interviewed the Administrative Unit in an hour-long virtual meeting to fact-check the Committee’s understanding and refine perceptions. The Administrative Unit presented answers to the Committee's questions and addressed other follow-up questions.

After the online interview, the Committee attended the final meeting to review the initial assessment in light of the interview and make any final adjustments.

A one-page summary of the Administrative Unit was developed based on the information from the self-assessment, the research group’s evaluation reports, and the interview. The Administrative Unit had the opportunity to fact-check this summary. The Administrative Unit approved the summary with no adjustments.

Limitations

The Committee judged that the Administrative Unit self-assessment report was insufficient to assess all evaluation criteria fully. However, the interview with the Administrative Unit filled gaps in the Committee's understanding, and the information was sufficient to complete the evaluation.

List of administrative unit's research groups

Institution	Administrative Unit	Research Groups
Norwegian Computing Center (NR)	Norwegian Computing Center (NR)	Statistical Analysis of Natural Resource Data (SAND) Department of Applied Research in ICT (DART) Statistical Analysis and Machine Learning for user motivated applications (SAMBA) Image analysis, Machine Learning and earth observation (BAMJO)

Terms of Reference (ToR) for the administrative unit

The board of Norsk Regnesentral mandates the evaluation committee appointed by the Research Council of Norway (RCN) to assess Norsk Regnesentral based on the following Terms of Reference.

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by Norsk Regnesentral as well as its relevance to institutional and sectoral purposes, and to society at large. You should do so by judging the unit's performance based on the following five assessment criteria (a. to e.). Be sure to take current international trends and developments in science and society into account in your analysis.

a) Strategy, resources and organisation

b) Research production, quality and integrity

c) Diversity and equality

d) Relevance to institutional and sectoral purposes

e) Relevance to society

For a description of these criteria, see Chapter 2 of the mathematics, ICT and technology evaluation protocol. Please provide a written assessment for each of the five criteria. Please also provide recommendations for improvement. We ask you to pay special attention to the following two aspects in your assessment:

1. Norsk Regnesentral has a long and proud tradition and responsibility as the foremost national competency centre for applied statistical modelling, including its convergence with machine learning and artificial intelligence.
2. Norsk Regnesentral's primary mission is to conduct valuable and highly relevant applied research in close partnership with Norwegian industry and society. Collaborations with Norsk Regnesentral should result in enhanced operational activities for private and public clients, manifesting in higher revenue, increased efficiency, or minimised losses, among other benefits. Conversely, applied challenges should provide feedback and stimulus for our basic methodological research, which, in turn, is vital for future applied use.

In addition, we would like your report to provide a qualitative assessment of Norsk Regnesentral as a whole in relation to its strategic targets. The committee assesses the strategy that the administrative unit intends to pursue in the years ahead and the extent to which it will be capable of meeting its targets for research and society during this period based on available resources and competence. The committee is also invited to make recommendations concerning these two subjects.

Documentation

The necessary documentation will be made available by the mathematics, ICT and technology secretariat at Technopolis Group.

The documents will include the following:

- a report on research personnel and publications within mathematics, ICT and technology commissioned by RCN
- a self-assessment based on a template provided by the mathematics, ICT and technology secretariat

Interviews with representatives from the evaluated units

Interviews with the Norsk Regnesentral will be organised by the evaluation secretariat. Such interviews can be organised as a site visit, in another specified location in Norway or as a video conference.

Statement on impartiality and confidence

The assessment should be carried out in accordance with the *Regulations on Impartiality and Confidence in the Research Council of Norway*. A statement on the impartiality of the committee members has been recorded by the RCN as a part of the appointment process. The impartiality and confidence of committee and panel members should be confirmed when evaluation data from Norsk Regnesentral are made available to the committee and the panels, and before any assessments are made based on these data. The RCN should be notified if questions concerning impartiality and confidence are raised by committee members during the evaluation process.

Assessment report We ask you to report your findings in an assessment report drawn up in accordance with a format specified by the mathematics, ICT and technology secretariat. The committee may suggest adjustments to this format at its first meeting. A draft report should be sent to the Norsk Regnesentral and RCT]. The Norsk Regnesentral should be allowed to check the report for factual inaccuracies; if such inaccuracies are found, they should be reported to the mathematics, ICT and technology secretariat within the deadline given by the secretariat. After the committee has made the amendments judged necessary, a corrected version of the assessment report should be sent to the board of Norsk Regnesentral and the RCN no later than two weeks after all feedback on inaccuracies has been received from Norsk Regnesentral.

Appendices

1. Description of the evaluation of EVALMIT
2. Invitation letter to the administrative unit including address list
3. Evaluation protocol
4. Template of self-assessment for administrative unit (short-version)

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