The Research Council of Norway

Evaluation of Mathematics, ICT and Technology 2023-2024

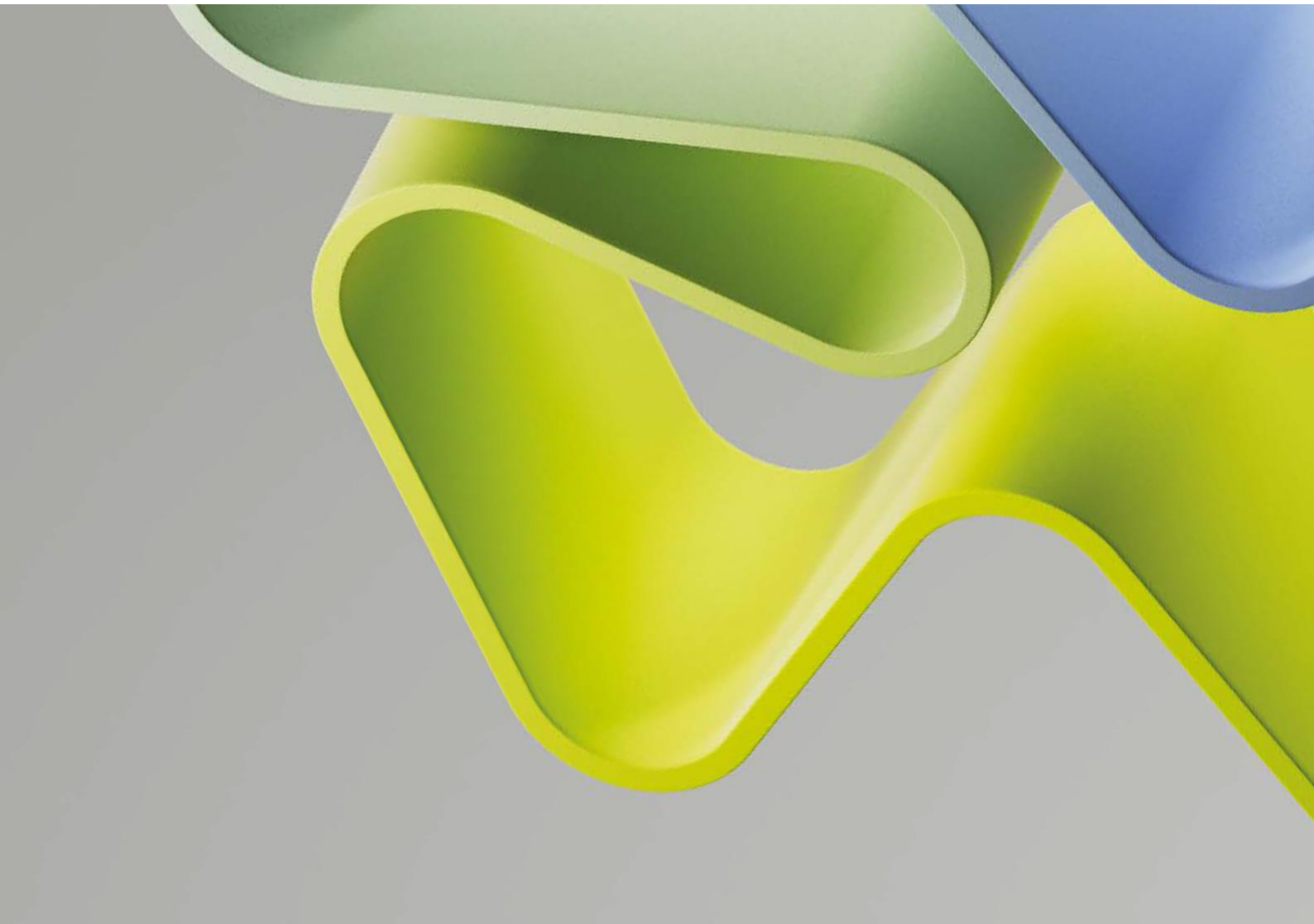
Evaluation Report for Administrative Unit

Administrative Unit: **SINTEF Manufacturing**

Institution: **SINTEF Manufacturing**

Evaluation Committee Institutes

December 2024



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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 has 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

SINTEF Manufacturing is one of six institutes within Corporate SINTEF. It is organised into three Research Departments and one Administrative Department. SINTEF Manufacturing consists of three Research Departments: Material technology, Industrial ecosystems and Production technology. The admin unit employs 93 staff total, of which 56 are researchers. They do not have any formal obligations for education, but they do host PhD students as part of their research projects in collaboration with NTNU.

SINTEF Manufacturing's strategy follows SINTEF's overarching vision of 'Technology for a better society', guided by the UN Sustainable Development Goals. The admin unit identifies four main strategic research areas (digital manufacturing, circular manufacturing, advanced manufacturing technology and advanced material technology) to achieve their social mission and recognise 8 prioritised research areas to be followed as a result. They identify a need for a balanced project portfolio, distributed over competence building and projects that utilise existing knowledge. The majority of their portfolio is funded by projects won in national and international competitions. Their researchers also participate in a number of national and international scientific organisations such as NFEA, CIRP and EFFRA to bring their research to forefront.

SINTEF Manufacturing has many collaborations with national and international partners, including other research institutes, universities, businesses and public authorities. Their project portfolio features many EU projects, and they have strong bonds with European Universities. They also participate in several international projects as partners and coordinators. SINTEF Manufacturing also collaborates with NTNU and have strong bonds with the Department of Mechanical and Industrial Engineering and the Department of Industrial Economics and Technology Management within Norway. Being the only manufacturing-specific institute in Norway, they are able to contribute to national manufacturing strategies, such as Grønt industriløft 2.0. Their research areas also contribute to European Roadmaps such as Manufacture Vision 2030.

SINTEF Manufacturing highlights many strengths and opportunities that allow them to be better positioned in the future. They have an increasing project portfolio with EU projects, especially with projects relating to the green transition, digital transformation and Horizon Europe. The unit also note their attractiveness as an employer and their strategic recruitment of PhD students since 2019. They have a large dissemination of their R&D results from their collaboration with industrial clusters and MTNC, and a high industrial impact from implementation. However, SINTEF Manufacturing note that the relatively small size of their institute makes it challenging to develop new research areas. They also highlight the low level of basic funding, and low manufacturing awareness from RCN calls.

Overall Assessment

Overall, there is a significant track record of high quality research activity in SINTEF Manufacturing and the unit should be proud of its staff and what they have and continue to accomplish. It is very clear that the unit plays a significant role in helping the overall SINTEF entity achieve its mission of providing technology for a better society.

SINTEF Manufacturing's remit is quite broad. There is a complex landscape of priority research areas, initiatives and strategic approaches. Such a multifaceted set makes it difficult to achieve all, and also makes it much more difficult for the strategic plan to truly inform the decisions about which the projects the unit should and should not take on, and how they should operate generally. There was a disconnect between (i) the highly developed strategic plan of the administrative unit and accompanying low-level firm actions ('subgoals') and (ii) reality as expressed by the Research Group assessments.

The unit seem to have an approach to project selection that is a combination of top down and bottom up. This is of course common across many units, but this unit could benefit from a narrowing of the strategic focus to help this guidance from the top down.

One overall challenge the evaluation committee encountered was finding very tangible examples, particularly in relation to tangible measures of impact. As will be shown in the report this was a point raised in multiple sections.

As requested in the Terms of Reference, the evaluation committee evaluated the future strategy, and the extent to which the admin unit will be capable of meeting their targets based the available resources and competence. In order for SINTEF Manufacturing to achieve its ambition of greater international participation in the particular areas it is important to diversify beyond what seems to be a high reliance on aluminium related research. There are good reasons for the aluminium focus, including Norway's traditional emphasis and a strong expertise within the group. However, it is clear that SINTEF Manufacturing's staff and existing technology and processes can easily diversify and further strengthen the unit's long term stability and resilience. Also, as stated in the unit's SWOT analysis, the current geopolitical situation makes friend shoring, near shoring and home shoring to Europe and Norway will increase demand for manufacturing R&D competence.

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

Recommendations

1. Appoint an advisory board to help with strategy formulation and advice of various activities and decisions.
2. Identify tangible measures in monetary terms, or in some other quantifiable way so as to be able to communicate the value of work to public citizens, potential partners, funding proposal evaluators etc.
3. Run training sessions or workshops on building and reporting impact cases.
4. Continue to diversify the unit's research activity research beyond aluminium.
5. Implement or update existing mechanisms for resource allocation and performance evaluation and mentoring to ensure junior staff have opportunities to engage with and subsequently lead project proposals and projects.
6. Explore what infrastructure is available internationally and evaluate the appropriateness and viability of using such infrastructure.
7. Continue to increase international collaboration both with industry partners and universities of international standing.

8. Introduce synergies so that a partner becomes involved in multiple activities such as funding, co-authoring, training and mentoring.
9. Examine on an ongoing basis some of the underlying measures regarding gender and diversity. For example, are all being given an opportunity to lead proposals and are actually leading proposals, managing others etc.
10. Set aside funding for specific training, and for involvement in various women's leadership networks and events, as well as events that consider all aspects of diversity and not just gender.
11. Rather than just delegate all decisions re open and closed publishing to project-specific steering committees, also monitor the overall degree of openness of the research activity of the unit.
12. Educating partners on the benefits of and responsibility to be more open.
13. Parse publications on an industry project, to ensure that those which can be open are. At present it seems that while some of the activity and resulting publications should be closed for various IP reasons, there is an opportunity to separately publish that which is not subject to such concerns.

1. Strategy, Resources, and Organisation of Research

This administrative unit is comprised of three departments, namely *material technology*, *industrial ecosystems*, and *production technology*. The main goal of the unit is "*Future* sustainable and competitive production solutions". This then divides into four overall strategic research areas. These are (i) Digital manufacturing, (ii) Circular manufacturing, (iii) Advanced manufacturing technology, and (iv) Advanced material technology.

It is clear from the self-assessment report and interviews that there is significant activity within all four, although in some cases there is significant overlap between the areas and how they are funded and implemented in practice.

1.1 Research Strategy

The goals of SINTEF Manufacturing clearly align directly with SINTEF's overreaching vision Technology for a better society.

One concern of the evaluation committee was how the unit and its three departments (material technology, industrial ecosystems, and production technology) manage to navigate the complex landscape in SINTEF with regards to the 'Prioritised Research Areas', 'Corporate Initiatives' and 'strategic approaches'. It is clear that there are many projects that align to these various sets of criteria and there is certainly significant research activity in each. One challenge though was to understand the degree to which the strategic goals related to institutional strategies and scientific priorities are met. The self-assessment report did not provide sufficient tangible examples of the actual value of the work being done- while undoubtedly there is much activity of very significant and in some cases transformative value.

In the interview with the unit, it seemed a challenge to elicit such tangible examples clearly. This is discussed in more detail in Section 4 of this report.

The self-assessment report also describes how a significant amount of the unit's activity is as a part of a larger, complex over-arching SINTEF initiative. Manufacturing is one of SINTEFs strategic initiatives, that provide multidisciplinary collaboration for complex challenges referred to in the self-assessment report as "One SINTEF". One cited example was a project in the area of defence. Another example was a recently terminated 10-year

project called Centre for Research based Innovation Manufacturing. The aim of this project was to show that advanced, sustainable manufacturing is possible in high-cost countries and was a collaboration between SINTEF Manufacturing (the co-ordinating host), Industry and Digital, and was worth more than €21.5m, with 14 partner companies. While this is obviously a very complex project to co-ordinate the administrative unit seemed to have a very strong management process in place, with a central governance aspect being a steering committee lead by one of the industrial partners addressed budget challenges that may have arisen from the SINTEF subsidiaries.

Another concern raised by the evaluation committee was the potential over-dependence of the unit on aluminium research, should there be a downturn in the aluminium industry. However, this issue was addressed by those interviewed who stated that, while there is an emphasis on aluminium, SINTEF Manufacturing has a wide competence, with research on steel aluminium, titanium, brass and plastic composites. Also, in Norway, aluminium is historically more important than steel, and the automative and defence industry partners have a high demand for aluminium parts. Also, the infrastructure in SINTEF Manufacturing is well equipped to deal with other materials.

The strategy of SINTEF Manufacturing ensures that the unit integrates emerging digital technology. At an over-arching strategic level, SINTEF has started a corporate initiative called data.sintef.no, which allows for the better controlling/storage of data/sharing of data with customers. At a more granular level, basic funding is used to fund some specific projects to implement emerging digital technology within the company. Modelling activities such as creating digital twins are becoming part of the projects. Co-pilot is being used for more day-to-day activities.

Recommendations:

- Unit members identify tangible measures in monetary terms, or in some other quantifiable way so as to be able to communicate the value of their work to public citizens, potential partners, funding proposal evaluators etc. This will help, not just with future assessments, but also when writing proposals, and disseminating the value of the work to customers, potential partners and citizens.
- Unit members attend training or practical workshops on how to write impact cases.
- Continue to diversify its research beyond aluminium. This should also align with the unit's internationalisation strategy, where there will be collaborative research in countries that unlike Norway are not so oriented to aluminium.
- Disseminate and publish these various activities as these approaches may not be common in other research centres and this unit can enhance their reputation in this area.

1.2 Organisation of Research

The administrative unit has a cohesive and adequate strategy for its research activities, recruitment, careers opportunities, mobility opportunities, and internationalisation. The self-assessment outlined very clearly the formal procedures for advancement and career progression, and also mentioned that advancement is assessed throughout the year and also as part of annual appraisal.

In terms of overall career development within SINTEF Manufacturing, there are paths for scientists, engineers, technical personal and administrative personnel. For a scientist wanting to be promoted to a research scientist, a formal discussion and evaluation is had within the department leadership group. If yes, the candidate and leadership group complete an application to be evaluated by institute. If no, they are given detailed feedback on the reasons

for this decision. Every researcher has a personal development plan which is discussed in an annual employee appraisal and a 'mini appraisal' every 6 months to follow up on progress.

At the interview it was stated that the choice of projects that a person works on can be made in collaboration with the researcher's leader to best suit the researcher's prospective career development e.g. choosing a project that needs a project manager for PM experience. Good female candidates are particularly considered for those who are working towards a senior position. Basic funding is also provided for researchers to achieve their goals. According to the responses at the interview with the group, the choice of promotion is based on a researcher achieving their goals, not based on budget.

In terms of facilitating the education of master students, training and mentoring of PhD candidates and post-docs/young researchers, SINTEF have no formal obligation to do so in the ToR. However, it is quite admirable that they have very extensive activities in this regard. They host students from universities such as NTNU and USN. 2 employees in SINTEF are also employed in these universities and so knowledge transfer from research to projects is facilitated.

It is also very clear the organisation of research contributes to the institutional strategies and objectives through large scale industry collaboration, generation of significant external funding.

While it was stated that each staff member will be assigned roles to best suit their promotion or career development, it is hard to imagine that there isn't some conflict between this very admirable approach and the commercial need to ensure that all projects are staffed by those most suited. In the case of the latter there may be instances where this does not align with the career development plans of all staff.

Recommendations to the administrative unit.

- Implement or update existing mechanisms for resource allocation and performance evaluation and mentoring to consider this possible tension when taking on new projects.

1.3 Research Funding

SINTEF manufacturing have been extremely successful in terms of funding income. Income in 2019 was over 23m NOK and has now grown to over 48m.

This is comprised of an increase in all sources, including basic grants, grants from the Research Council of Norway and also from EU sources. The latter is particularly noteworthy, as, this now ensures SINTEF Manufacturing are less dependent on international sources of funding.

There was very little information regarding how this was done in the self-assessment report, but the interview with the group showed that this was a very intentional strategy underpinned by significant training.

It is also noteworthy that the group are trying to ensure that they are not dependent on one or two individuals to submit proposals and obtain funding- an issue that is very common across institutes. One approach by the group is to involve junior staff in writing proposals to ensure they gain this valuable experience. This is certain admirable although to date it is not clear if these newer group members are leading projects in their own right, rather than just learning from others.

Recommendations:

- Involving junior staff in proposal writing,

- Develop a strategy to identify opportunities for junior staff to be lead investigator on projects. This may begin by choosing smaller or easier grants to build that experience of managing projects as opposed to just writing proposals.

1.4 Research Infrastructures

SINTEF Manufacturing is partner in the national research infrastructure (RI) Manulab, with infrastructure located at their premises at Raufoss and Trondheim, in addition to access to relevant Manulab-infrastructure at NTNU in Trondheim and Gjøvik. SINTEF Manufacturing hosts Scanning Electron Microscope (SEM) research infrastructure at Raufoss, and is part-host, together with NTNU, for robotics research infrastructure in Trondheim.

The majority of the research done at SINTEF Manufacturing is using existing and available infrastructure instead of advanced instruments/manufacturing technologies. Most industry projects require the modification of existing technology infrastructure, instead of requiring the invention of new technologies.

In the self-assessment report, it is stated that “Participation in international infrastructures “Not relevant for SINTEF Manufacturing.”. This was discussed at the interview and one of the logical reasons given for this is the nature of some of SINTEF Manufacturing research. It is important that the research is done in house, as it is based on material science, production technology, and the day-to-day practicalities are more easily done in house. It was also explained that there is some use of international infrastructure in partnership projects.

Recommendations:

- While it is clear that the nature of the central research at SINTEF Manufacturing reduces the possibility to draw on international infrastructure, the unit should explore which research could draw on such infrastructure.
- To obtain synergies, the group should explore what infrastructure is available internationally and evaluate the appropriateness and viability of using such infrastructure.

1.5 National and international collaboration

The unit have a significant list of high profile national and international collaborations. These range from short term partners on one off projects to very deep long term collaborations. In the case of the latter (such as NTNU) there are staff with joint appointments, ensuring very tightly fused collaboration and engagement.

A common challenge of collaborations with industry and universities is how to handle the tension between industry clients needing quick results and academic publications needing lots of time for research/review process. In SINTEF Manufacturing there is a well-balanced project portfolio, which contains both long term, high quality research and also short term projects funded by industry. Basic funding used to ‘balance’ the portfolio, as it is put into scientific development and publications, where in some instances there is not enough funding for long-term, high-quality projects to be published.

One possible concern in the self-assessment report was that SINTEF Manufacturing researchers seemed to co-write papers with national rather than international partners (which is opposite to the trend of other SINTEF subsidiaries). However, at interview it became clear institute has been transformed from being mostly working with national customers to now mainly international. Therefore, it is logical to expect that there will be a significant increase in co-authorship with international partners in the coming years.

Recommendations:

- Continue to increase the ratio of international to national collaboration.
- Introduce synergies so that a partner becomes involved in multiple activities such as funding, co-authoring, training and mentoring.
- Consider more collaborations with international universities.

1.6 Research staff

From the self-assessment report, it is clear that the group is unbalanced in terms of gender and further, the representation of females drops at more senior roles (25% at level 3 and 0% at level 4. The fact that 40% of Level 1 staff are female shows that this is starting to be addressed.

The self-assessment report did not contain a lot of current actions to address these issues. However, at interview these were teased out in detail. From the interviews it seems the group have the following activities or procedures in place. First, HR is included early in the recruitment process to ensure equal treatment of candidates and employees. Second, candidates and new employees are informed early about career opportunities and how to work towards promotion. Third, female workers are actively worked with to assess career development, and 'nudged' to apply for senior positions if they are qualified. Fourth, suitable candidates are put in contact with senior or chief scientists to support them in their career development and given management support in writing their applications. Finally, gender quotas are not used in employment – but if there are two equal candidates, then the woman is given priority.

Recommendations:

- Examine on an ongoing basis some of the underlying measures regarding gender. For example, how many females in junior staff positions, (and indeed junior staff generally) are being given an opportunity to lead proposals and are actually leading proposals, managing others etc.
- Set aside funding for specific training, and for involvement in various women's leadership networks and events, as well as evets that consider all aspects of diversity.

1.7 Open Science

While the self-assessment report was quite vague on the detail of the open science policy and approach at SINTEF Manufacturing, there was some clarity provided at the interview. SINTEF has policy which is to be "as open as possible, but closed as necessary", which as stated in the unit's own SWOT analysis, is an identified weakness and is inhibiting the publication of all work. Therefore, there are very different approaches taken to open science depending on the project. As an example, everything that is directly funded by the NRC is open. However, some projects are highly competitive for companies involved. In these cases, each project will have a steering committee, and has the right to accept/refuse, e.g. if the company wants to patent the research.

Also, SINTEF Manufacturing seem to prefer archival publications as opposed to golden open access. This is partially due to the higher proportion of directly funded industry projects. Often publications are co-authored with industry partners, and they often have strong preferences as to the format of the publishing.

While it is positive to have a steering committee guiding the open science policy in each project, and it is understandable that industry partners will have strong views which should

be considered, it can be inferred that these steering committees are veering more toward closed than open.

Rather than passively adhere to (some) industry partners' preferences toward closed, the admin unit should offer some ways of educating partners on the benefits of and responsibility to be more open.

At present it seems that while some of the activity and resulting publications should be closed for various IP reasons, there is an opportunity to separately publish that which is not subject to such concerns.

Recommendations on how to promote open science

- Monitor the overall degree of openness of the research activity of the group
- Explore how to parse publications on an industry project, to ensure that which can be open is.

2. Research production, quality and integrity

SINTEF Manufacturing consists of three Research Departments: Material technology, Industrial ecosystems and Production technology. The admin unit employs 93 staff total, of which 56 are researchers.

In terms of the quality of their work, a review of their outputs shows that there is a very diverse set of research activities with different methods, goals and outlets. The group do not seem to have a very focused strategy in terms of what outlets they publish in, although this is to be expected to some degree in a group that is aimed at different organisations, each with very different needs and problems. They have a large dissemination of their R&D results from their collaboration with industrial clusters and MTNC, and a high industrial impact from implementation. It is clear that the industry impact of their work is of a very high quality. That is not to say that is not of high quality in terms of academic quality - the output is just quite varied in this regard. The majority of their portfolio is funded by projects won in national and international competitions. Their researchers also participate in a number of national and international scientific organisations such as NFEA, CIRP and EFFRA to bring their research to forefront. This again highlights the quality of the unit's research. Regarding the quality of the research in terms of translation to teaching and education, SINTEF Manufacturing do not have any formal obligations for education, but they do host PhD students as part of their research projects in collaboration with NTNU.

In terms of research integrity, SINTEF Manufacturing adheres to the SINTEF organisation's Code of Conduct and over-arching strategies and planning documents, which the evaluation committee find to be satisfactory. These address various aspects of research integrity. There weren't too many direct references to the code of conduct throughout the various parts of the self-assessment report, but the committee feels that many of the actions and procedures documents throughout are aligned with the Code of Conduct and so this link is there throughout, even if implicit. Also, SINTEF Manufacturing has many collaborations with national and international partners, including other research institutes, universities, businesses and public authorities such as NTNU and have strong bonds with the Department of Mechanical and Industrial Engineering and the Department of Industrial Economics and Technology Management within Norway. These collaborations and being subject to the ethical and integrity requirements of those institutions will further ensure the integrity of the work.

It is expected that the research quality of the group will be maintained into the future. SINTEF Manufacturing highlights many strengths and opportunities that allow them to be better positioned in the future. They have an increasing project portfolio with EU projects, especially with projects relating to the green transition, digital transformation and Horizon Europe.

2.1 Research quality and integrity

Research group Industrial Robotics and Automation (RobAuto) overall assessment

The research group aims to develop advanced production technologies to support Norway's industrial innovation, focusing on adaptable production systems. Despite intentions to grow to 15 members by 2027, concrete strategies to achieve their objectives are lacking. Proposed key performance indicators for research excellence include project grants, impactful publications, collaborative partnerships, technological innovation, real-world applicability, talent development, external recognition, and continuous improvement. However, the research group did not sufficiently elaborate evaluation criteria and thresholds to make such indicators effective for the growing of the group. These are some weaknesses of the research group. Collaboration extends nationally and internationally, with funding mainly from commissioned research and EU Horizon 2020 proposals. Despite a decrease in funding from the RCN, international reputation is growing, which is a strength. Publications demonstrate appreciation within the research community, but the group's contribution is not clearly highlighted. Involvement in conferences such as Technical Track Chair or International Program Chair should be concretely pursued, the current lack of which is a shortcoming. The group has participated in ten successful innovative projects, showcasing strong interaction with international research groups. This is a strength. No monographs have been produced, which is a minor shortcoming.

Research group Digital Production (DP) overall assessment

The research group’s organisation is suitable to conduct its research but could benefit from more involvement of PhD-students. Given that the group consist of only 11 researchers, it is unclear from the self-assessment if the distribution over 2 main offices, and an additional 2 satellites offices create any challenges. The digital production group contributes significantly to the field, with presentations at relevant conferences and journals published at a high level. The DP group contributes strongly to its main research areas both from a national and international perspective. The group also actively participates in the research community and in professional networks, such as IFIP and SIG, as well as in community services such as editing special issues and being member of committees. Their interdisciplinary and international collaboration is strong. The group clearly have made substantial contributions to various areas of society, both in Norway and internationally, particularly with focus on sustainable manufacturing. From the self-assessment the level of user-involvement is less clear.

3. Diversity and equality

Overall, the self-assessment report details some general initiatives regarding diversity and equality. These include statements such as “SINTEF aims to be an attractive workplace” and refers to the fact that equality and diversity is a part of the People Strategy, the HR Strategy, and the Gender Equality plan. It states that “all employees are expected to contribute to diversity”.

However, these are described in very abstract terms, and it is hard to see detail on tangible examples of what is being done. There is an inclusion program and in the monetary compensation policy there is a framework to unsure no unjustified differential treatment.

Given that there is a distinct lack of diversity in the group, particularly at senior level's 3 and 4, the evaluation committee would have expected to see this discussed explicitly, with specific actions or plans to address this issue.

Recommendations:

- Implement specific initiatives to address the lack of female representation at level 3 and 4 (currently 0% at level 4)
- In a future self-assessment effort, ensure that the group document tangible examples of equality and diversity initiatives rather than broad references to policies.

4. Relevance to institutional and sectorial purposes

The self-assessment report outlines various ways in which the institute contributes to the manufacturing sector. This includes both Norwegian bodies such as the Ministry of Trade, Industry and Fisheries and also European initiatives such as the Manufacture Vision 2023 and Made in Europe as well as the framework call on 'key enabling technologies for Europe's Technology Sovereignty.

A limitation of the self-assessment report is a lack of tangible examples of how the unit contributes to the sector. At interview this was discussed, and numerous examples were given. For example, the unit has developed a different casting method of aluminium using syphoning, removing any need for machining the surface of the aluminium ingot. Members of the unit explained that this has essentially removed an entire production stage for the manufacturing of automotive parts. This means the manufacturer of the ingots can sell a unique product, and the manufacturer of the automotive parts has reduced waste and faster production. It seems clear that this is very valuable. It proved challenging to find tangible examples of this at the interview or in the self-assessment report. The evaluation committee therefore suggest that the unit members identify tangible measures in monetary terms, or in some other quantifiable way so as to be able to communicate the value of their work to public citizens, potential partners, funding proposal evaluators etc.

Another example provided by the unit at interview was a collaboration with a shipyard in Norway has allowed them to set up an automatic welding line for the automatic/robotic welding of the undercarriages of offshore windmills. Again, it proved challenging to find tangible examples of this at the interview or in the self-assessment report.

These examples undoubtedly provide value to the various institutions and sectors in questions.

Recommendations

- Identify tangible measures in monetary terms, or in some other quantifiable way so as to be able to communicate the value of their work to public citizens, potential partners, funding proposal evaluators

5. Relevance to society

It is clear from the self-assessment report that the unit contribute significantly to the Norwegian societal policy. This includes evidence in terms of strengthened competitiveness and innovativeness (through the development of leading manufacturing technologies. It also includes various aspects of sustainability through initiatives such as sustainable product development, circular design strategies and development and evaluation of green taxonomies. Finally, they contribute through high quality engagement with research and higher education institutions (PhD and Masters students as well as staff in SINTEF having part-time positions in 2 universities.

They are particularly strong in terms of 'key enabling technologies.

The self-assessment report doesn't elaborate on SDGs specifically although it is clear that the above examples also apply to various SDG goals also.

The impact cases also illustrate the relevance to society of the unit. All 3 cases have strengths and weaknesses though. The first is strong but perhaps too broad, the second seems very strong also but doesn't give tangible metrics or evidence of impact and the 3rd does but without necessarily showing clearly the source of what are very impressive metrics.

Recommendations:

- Take the strengths from each and using them to improve the others for any future self-assessment report.
- To narrow the scope of the presentation of individual impacts to allow authors and readers to home in on a smaller number of industry impacts and give more tangible detail of what the new products and processes are and what 'recruitment' means.

5.1 Impact cases

Comments to impact case 1: SINTEF Manufacturing

This impact case describes the overall activity of SFI Manufacturing. There is certainly strong evidence of impact. There is a government white paper and many other publication outputs. What is potentially very impressive is the list of 8 companies that have implemented either a new product, process or 'recruitment' although it is not clear what 'recruitment' means.

The self-declared period of the impact is however very unclear. In various parts of the impact case the period referred to as "2018-2022", "2016-2022", and "2025-2023" – the latter is clearly a simple typo error. However, the impact case refers to work as far back as 2008.

Overall, this impact case is a lot more broad than usual and covers almost everyone and everything in the institute.

Comments to impact case 2: CIRCULAER

This impact case is based on a project that combines lean and circular thinking. It is a very innovative project, and the impact is nicely demonstrated through 2 impact use cases, namely Laerdal Medical and Haugstad Mobel.

The impact cases clearly align with the overall strategic goals of SINTEF Manufacturing.

The quality of the impact is exemplified by publications in high quality outlets including most notably the International Journal of Production Research. In terms of teaching impact, it was

also published and presented at a Lean educator conference in 2021 and the IFIP WG5.7 Conference in France.

The process of the impact is described very clearly in terms of setting up the project and developing and testing hypotheses. It would have been great to have seen some tangible quantitative or qualitative evidence of the benefits of the projects. It is highly likely that they are there given the way the project is described, but some objective evidence of impact would have strengthened this case a lot.

Comments to impact case 3: Quick Response 4.0

The Quick Response 4.0 project seems very exciting. It seems to combine thinking on TQM, Lean, and Six Sigma. However, given that these are each very comprehensive and complex programmes, it is unclear how these are combined and synthesised or modified. It also claims that the project takes these “to the next level” although the evaluation committee recommend for future impact cases that the authors try to be clearer about, they mean by this claim and how they substantiate it.

A really nice feature of the case is the clear statement of improvements in metrics: “77% lead time reduction, 50% waste reduction, doubling of earnings, 30% increase in turnover and 40000m2 reduction of used area”. However, it is not clear where these very impressive metrics came from. Was it from a single company or project?

They refer to other educational institutions showcasing results, but it is not clear if these are showcasing the results of this project specifically or TRM generally. If the former ,then these shouldn’t be claimed as impact evidence of this project.

Methods and limitations

Methods

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

The documentary inputs to the evaluation were:

- Evaluation Protocol that guided the process
- Terms of Reference
- Administrative Unit’s self-assessment report
- Administrative Unit’s impact cases
- Administrative Unit’s research groups 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 minor adjustments for clarity.

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
SINTEF	SINTEF Manufacturing	Digital Production (DP) Industrial Robotics and Automation (RobAuto)

Terms of Reference (ToR) for the administrative unit

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

Assessment

You are asked to assess the organisation, quality and diversity of research conducted by SINTEF Manufacturing AS 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 2 aspects in your assessment:

1. Strategy and relevance to society

SINTEF's corporate strategy, adopted in 2019, is guided by the UN Sustainable Development Goals (SDGs). The goals refine SINTEF's overreaching vision *Technology for a better society*, which is also adopted by SINTEF Manufacturing AS.

SINTEF Manufacturing AS have focussed on research activities supporting *green and digital transformation*, which is an important enabler for social benefits and competitiveness for businesses, industry, and society:

- Contribute to increasing export revenues from Norwegian industry.
- Contribute to increased processing of raw materials in Norway.
- Transition to products and services that are part of circular value chains.
- Contribute to the new green value chains with our expertise.

This transition requires new solutions, new technology, new forms of collaboration and new research-based knowledge.

2. Strategy and relevance to institutional and sectoral purposes

Our social mission and our strategic focus areas are closely interlinked, and our main goal of *Future sustainable and competitive production solutions* will be achieved through our four main strategic research areas:

- Digital manufacturing
- Circular manufacturing
- Advanced manufacturing technology

- Advanced material technology

To realize these strategic areas, we have identified 8 prioritized research areas to be followed up by systematic emphasis of scientific development, recruiting and investments in research infrastructure, where the two first areas are subject to this evaluation:

- Industrial Robotics and automatization
- Digitalisation in manufacturing
- Circular economy and sustainability in manufacturing
- Integrated value chains and effective production
- "Produktnære lettmaterialer" (trenger en god engelsk oversettelse)
- Forming, machining, and joining
- Industrial product- and process modelling
- Metal additive manufacturing

In addition, we would like your report to provide a qualitative assessment of SINTEF Manufacturing AS 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 SINTEF Manufacturing AS 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 SINTEF Manufacturing AS 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 SINTEF Manufacturing AS and RCT]. SINTEF Manufacturing AS 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 SINTEF Manufacturing AS and the RCN no later than two weeks after all feedback on inaccuracies has been received from SINTEF Manufacturing AS.

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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