

Midway evaluation of 17 Centres for Research-based Innovation (SFI-III)

Evaluation
Science and the Research System

 **Sf i** Centre for
Research-based
Innovation

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The Research Council of Norway
Visiting address: Drammensveien 288
P.O.Box 564
NO-1327 Lysaker

Telephone: +47 22 03 70 00

Telefax: +47 22 03 70 01

post@rcn.no

www.rcn.no

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Preface

The first SFI-scheme funding call was issued in 2005 and 14 centres were active in the period 2007-2015 (SFI-I). The second funding call was in 2010, and seven centres began their activities during 2011 (SFI-II). In 2014 a third funding call was launched, and 17 centres were selected for activities beginning in 2015 (SFI-III). This evaluation report presents the midway evaluation of the last 17 centres.

The SFI-scheme is intended to promote innovation by supporting long-term industrially-oriented research and forge close alliances between research-active enterprises and prominent research groups. The scheme is also expected to enhance technology transfer, internationalisation and researcher training.

The centres are co-financed by enterprises, host institutions and the Research Council. Enterprises participate actively in a centre's governance, funding and research. The main criterion for selecting centres is their potential for innovation and value creation. The scientific quality of the research must be of a high international standard. When the centres are established, they are given a contract for five years. Based on a successful midway evaluation, the contract may be extended for another three years.

In this midway evaluation of SFI-III, each centre has been evaluated by a panel of four international experts; two scientific experts with expertise to evaluate the research activities of the centre, and two generalist experts with experience from similar programmes for university - industry research collaboration.

The report from the evaluation panels has two main purposes:

1. It will form the basis for a decision about whether to continue the individual centre for the remainder of the overall eight-year term, or to close it down after five years.
2. The evaluation will give advice to the centres on aspects of their activity that should be improved.

It is the Research Council's decision alone to prolong individual Centres, the evaluation panels were asked not to comment specifically on this issue.

The Research Council of Norway wants to express appreciation to the international evaluators. Special thanks go to Professor Alison McKay, Professor Mary O'Kane and Professor David Williams for their professional leadership of the panels and the process of writing the report. Thanks goes also to Dr. Mattias Lundberg who participated in 14 of the 17 centre evaluations and contributed with invaluable experience, coordination and calibration among the panels. All evaluators have been able to communicate well with the centres and have produced a report that will be of value both for the further activities of the centres and for the SFI-scheme administration.

John-Arne Røttingen

Chief Executive

Contents

Overall report from generalist evaluators	1
BigInsight – Statistics for the knowledge economy	8
Metal Production	13
C3 – Centre for Connected Care	19
EXPOSED – Exposed Aquaculture Operations.....	25
Foods of Norway	31
CtrlAQUA – Centre for Closed-containment Aquaculture.....	38
Klima2050	48
CASA – Centre for Advanced Structural Analysis	55
CIUS – Centre for Innovative Ultrasound Solutions	59
SUBPRO – Subsea Production and Processing.....	65
Centre for Offshore Mechatronics	69
SIRIUS – Centre for Scalable Data Access	74
SFI Manufacturing.....	81
CIRFA.....	87
Smart Maritime.....	92
iCSI	99
MOVE – Marine Operations Centre.....	104
Appendix.....	110
A. Terms of reference	
B. Templates	
C. List of Centres and Experts	

Overall report from generalist evaluators

1. Introduction

The 17 centres for Research-Based Innovation (SFI) supported by the Research Council of Norway (RCN) were evaluated on one-day site visits from March 4 to April 11 2019, approximately 3½ years after they were started and about midway through the planned eight-year program. The evaluation had two main purposes:

- to form a basis for a decision by RCN whether to continue financing of each individual centre for the final three years of the eight-year term;
- to comment upon and give advice to the centres in the form of recommendations on their activity and how it should be improved.

Each centre was evaluated by a team of four experts. Two were experts with the competence to evaluate the Centre from a scientific point of view and two “generalists” had experience from similar programs for university-industry research collaboration on an international level. The generalists evaluated the management, organisation and funding of each centre, and also its interactions with user partners in terms of mutual mobility of researchers, transfer of results and stimulation of innovations. Each site visit followed the same procedure which included three interview sessions: a two hour morning session mainly addressed research at the centre and, after lunch, there was a one hour meeting with PhD students and postdocs followed by a two hour discussion on management and organisation of the centre, knowledge transfer and innovations in the user partners. The reports of the evaluation teams are based on these interviews as well as on the extensive written reports and self-assessments supplied by each centre beforehand. In some cases, centres also subsequently supplied further information as requested by the evaluation team. A first draft of the report was compiled in the evening after the site visit. The draft report was finalised by email between the members of the evaluation team and submitted to RCN for fact checking by the centre before being finalised.

We were impressed by the quality of the written material, including the user feedback and the SWOT analyses, supplied by the centres as well as by the well organised and informative site visits. We thank the centres and RCN staff for the efficient organisation of the visits and overall evaluation scheme. Our particular thanks go to Liv Jorunn Jenssen, who represented RCN at almost all of the evaluations, for her quiet and efficient management of the arrangements and for being instrumental in creating the open and informative atmosphere prevailing at all our meetings with the centres. In addition, we also appreciated the support and insights from the RCN observer in the board for each centre.

In the opinion of the generalist evaluators, the evaluation did identify the progress, strengths and weaknesses of the centres and the SFI program as a whole. We would also echo the many comments on the scientific excellence of the work in the centres made by the scientific experts in the individual reports. We felt that the evaluation process was well designed to enable us to provide feedback, advice and recommendations to both the individual centres and to the RCN. We have, however, identified some small opportunities to improve the review process such as the clear reporting of associated projects as recommended below.

2 Overall impressions of the program and centres

The SFI program requires that centres carry out high quality research relevant to their end user partners but makes those partners responsible for turning that research into innovations that deliver societal value that draws, as necessary, on the centre through such mechanisms as industrial PhDs and associated projects. This is unusual in national competence centre schemes; Norway is taking a leading role in this form of innovation and value creation.

We were impressed by the scientific quality, knowledge transfer activities, and leadership in the majority of centres.

Across the centres there were many examples of good practice that should be captured and shared perhaps more than at present in order that current and future centres can build upon them. For example, the dissemination of the excellent mentoring and diversity approach demonstrated in SIRIUS and the research training scheme in KLIMA 2050 could be shared across all the SFI centres and more widely. In addition, we saw synergies across the scientific activities within centres. For example, links between EXPOSED and CtrIAQUA could be strengthened as could links between BigInsight, Offshore Mechatronics and SUBPRO on the processing of data from multiple sensors. There are also clear opportunities to more closely and explicitly link the activities of centres operating in the same sector, for example maritime.

Recommendation 1: That RCN encourages SFI centres to work together where appropriate. For example, centres should be encouraged to further develop collaborative associated projects and/or joint PhD student projects or training activities.

3 Internationalisation

The majority of the centres include scientists with strong international reputations and the centres benefit from their international networks. Within the centres themselves, however, it was not always clear how visible the centre itself was in these networks or how the centre funding had improved researchers' opportunities for collaboration with international research groups.

Much of the international activity was centre specific and frequently built upon the personal networks of the senior investigators. While we recognise that in many cases international relationships will be opportunistic, this makes the process somewhat ad hoc. This has the consequence of making the overall program appear to have a less strategic approach to internationalisation than it could have, apart from the encouragement of centres to actively participate in European programs. It was also noticeable that, while there were a number of excellent individual instances of good international experience and research secondment, many of the PhD students, because of pressures to complete their research, were not actively encouraged to seek international experience or did not feel that they had the time for such activities. This may have long term adverse effects on the competitiveness of applied research in Norway and addressing it is an opportunity to increase the excellence of the work of the program. Consequently, we recommend (in Recommendation 2) that SFI takes a more strategic approach to internationalisation by making it a more significant part of proposal assessment by, for instance, requiring a strategic plan as part of a proposal and by considering specific initiatives to promote international exchanges for early career researchers. This is also discussed in section 4.

An important means of calibrating and developing the international profiles of the centres is through their International Scientific Advisory Committees (ISACs). We were surprised and disappointed by the apparent reluctance of even some of the strongest centres to appoint an ISAC and require them

to meet face-to-face with centre researchers and boards at least once per year. In addition, some ISACs did not formalise feedback in writing.

Recommendation 2: That SFI takes a more strategic approach to internationalisation by making it a more significant part of proposal assessment and by considering specific initiatives to promote international exchanges for PhD students and early career researchers within the SFI program.

Recommendation 3: That RCN makes it a requirement for each of the centres to have an International Scientific Advisory Committee (ISAC) and requires that this ISAC meets annually and prepares a written report that is available to RCN once agreed. This ISAC should be gender balanced and established from the first day of centre funding.

4 Researcher training and recruitment

We met many impressive PhDs and postdocs and saw many examples of good practice in researcher training for careers in academia and public and private sector user organisations. However, overall, the direct participation of PhDs in industry and the number of international exchanges were disappointing. A frequent explanation for this was that students have to submit their PhDs within three years of starting (or four if their contracts include a teaching component). Contacts with industry were also frequently at arms-length or indirect. Good practices that could be adopted by all centres include the design of international exchanges where the student carried on their PhD research abroad and/or including in PhD contracts an additional period (e.g. 3 months) either as a pre-research period of immersion in the work of the industrial partner to better define the work of the subsequent research project and increase its relevance or, as a postdoc (after their PhD submission), working with industry on knowledge transfer activities. In the user driven world of SFI and comparable international initiatives, it is essential that researchers have some direct experience of the reality of their users. Such activities also increase the employability of researchers.

In several of the centres there were industrial PhDs either in the centre itself or working on associated projects. In discussing this issue, industry representatives indicated that they found that these centre-connected industrial PhDs are an excellent way to build highly skilled capacity in their companies.

It was also clear that there were some high performing postdocs in a number of centres and that, in a very small number of cases, these early career researchers had secured their own independent funding.

Recommendation 4: That RCN work with the centres to establish ways to enhance the understanding and experience of industry by academically based PhD students.

Recommendation 5: That RCN encourages centres to work with their end user partners to boost the number of industrial PhDs associated with the centres.

5 Visibility of the SFIs within Norway

The visibility of centres within their host institution and partner organisations was excellent in all cases. However, there remain opportunities to improve the wider, national visibility of the centres with, for example, potential user organisations in industry; the public sector outside the partner organisations; and the wider public.

The scientific output of the SFI program is excellent with significant numbers of both journal and conference papers and a number of books. However, the way that the centres present and report

this can in many cases be improved by the acknowledgement of the funding scheme in all publications, by reporting bibliometric data of citations for example, and identifying when papers are 'featured' papers in journals or prize winning.

The total investment to date in the SFI program (SFI I-III) is more than 7 BNOK over the period 2007-2023 if all the contributions of RCN, universities, research institutes and industry are taken into account (grants and allocations). Measuring the return for this kind of large investment is methodologically difficult with a high uncertainty given that the time from intervention to ultimate impact can be decades. Such impacts are also dependent upon commercial decisions and other economic conditions. However, we encourage the SFI program to gather "hard facts" on its impact on industry for future policy making. We also suggest that RCN facilitates structured interactions between key industry figures with experience of SFIs, policy makers and relevant government departments to sustain this form of important investment and ensure its further development.

Centres should also be encouraged to be more visible to the public in order to communicate the societal benefits of applied research and working with industry, to encourage changes in gender balance in applied research and industry, and to promote education and employment opportunities.

There are also opportunities to improve the visibility of centres to other Norwegian universities in particular as a means of encouraging and improving the quality of future applications.

6 Organisation, board and management

The SFI program has well proven organisational models for its centres that are complemented with other, also well proven, processes including those to promote interactions between internal and external stakeholders such as biannual whole centre meetings and the use of international advisory committees.

Successful centres have also developed successful approaches to resource (both people and financial) management, administration, the use of PhD and masters student projects, and the management of intellectual property and publications. The centres have also established a range of technology transfer mechanisms, for example associated projects, that are well suited to Norwegian industry and other users (see also the recommendation 8 below). We encourage SFI to work with the centres to continue to evolve and improve these processes, and ensure that best practice, perhaps as a 'tool box', is captured and communicated across the centres and also to those who are considering applying in future. We recognise that there is not a one size fits all model for centres, that any best practice model should not be applied without question to future centres, and that such a model should not form a set of requirements to be fulfilled in the application process.

All centres had a well-defined organisational structure that included a board where, apart from some cases, the chair was a representative of a user partner organisation. This must be continued. Many of the Directors we met combined good leadership, management, and people skills with scientific excellence. We also met a number of strong scientifically trained supporting staff. This in combination with the excellence of the academic staff, the pragmatism and good practice of institutes such as SINTEF, and the support of user partners, meant that almost all of the centres were effectively managed.

We encourage RCN to continue its best practice of having an observer who is present at centre board meetings. This was valued by all centres for two major reasons. Firstly, the RCN observer acts as a useful named point of contact within RCN to increase alignment with the objectives of the program, provide continuity, and give insights into emerging relevant opportunities. Secondly, by gaining early

insights into any risks in a centre, the contact can support the centre in either resolving or mitigating them.

Recommendation 6: That RCN, working with the centres, develops a best practice 'tool-box' for centre operation both to improve the performance of current centres and to inspire the development of future centres and directors. This should not impose 'one size fits all' practices on centres or become a set of requirements to be fulfilled in the application process.

7 Innovation and value creation

The tight coupling with end user partners is an essential and laudable element of the SFI program. The centres have a variety of good processes for monitoring and stimulating knowledge transfer to partners to accelerate innovation. This variety is a strength of the SFI program as it allows individual centres to respond to the specific needs of different sectors and the different ways of working in scientific disciplines. However, we saw opportunities for improvement in most of the centres that would lead to improvements for the SFI program as a whole. The centres have many common innovation issues including recruitment and mobility; verification of simulation results; proof of principle research; pilot testing and the use of demonstrator projects; patenting and intellectual assets in projects; and start-ups. These should be discussed by all centres even if the importance and implications of resulting actions are different from centre to centre.

Recommendation 7: That RCN formalises exchange of experience between all centres to improve the overall SFI program capacity for knowledge transfer.

8 Reporting and the Review Process

As indicated above, the evaluation process is a proven one, but there are some small and important ways in which it could be improved. The most significant of these is that the origin of associated projects is more clearly reported, see Recommendation 8 below. This is important to emphasise a key component of the added value of a centre and the program and to engage new partners. There are also important opportunities for centres and the program to more systematically analyse the user feedback forms (SFI Manufacturing showed best practice in this) and for RCN to correlate this feedback with the results of the process reported here, see Recommendation 9 below. Also given the volume of electronic paperwork involved in the review, it is important that this is electronically searchable, see Recommendation 10 below.

We would also encourage all of the centres to be more confident in the communication of their scientific highlights and the excitement of their science to the visiting reviewers.

Recommendation 8: That RCN requires all centres to report concurrent projects in three categories:

- (i) projects that started due to substantial results (knowledge transfer) and discussions from the centre;
- (ii) projects that started with only discussions from centre partners (but without any directly produced knowledge transfer from the centre);
- (iii) projects that start outside the centre with potential connection and knowledge transfer (both ways).

Recommendation 9: That RCN investigates whether there are any correlations between the end user survey results and the centre evaluations.

Recommendation 10: That RCN requires centres to submit PDF versions of their reports in a form where text, apart from in diagrams, is searchable.

9 Planning for the next financing period and beyond

The majority of centres have been slow in making an exit plan for after the eight year funding period. We suggest that, for future centres, RCN requires more attention to this issue before the mid-term evaluation and, as a matter of urgency, ensures that all the centres in this evaluation make a serious start on this activity in 2019.

Recommendation 11: That RCN ensures that all centres in this evaluation start to seriously address exit planning in 2019.

10 Gender

Gender balance was good in many centres and generally appropriate in all the centres recognising some of the industrial sectors engaged in the centres are further ahead than others. It was clear to the evaluation teams that the centres had good awareness of the issues and ideas involved, and a willingness to contribute to addressing imbalance both in the short and long term. While we recognise the complexity of the problem, given the importance of the centres for researcher recruitment, knowledge transfer and their closeness to industry, there is a real opportunity for the centres to be role models and change agents within the Norwegian system. We therefore encourage RCN to help research areas and industries that are lagging to get more exposure to concrete ideas that will improve gender balance. These include information, advertising and recruitment policies; mentoring programs; gender awards; and other best practice. RCN should consider investing in short term social science research capacity in domains that are particularly impacted to deliver insights with the potential to change the situation.

Recommendation 12: That RCN identifies domains with gender imbalance and invests in specific actions to start a change process with clear goals to accelerate change. Some SFI-Centres could act as role models for the Norwegian research and innovation landscape.

11 Conclusion and recommendations to RCN

The evaluation team was impressed with the overall program, most of the centres and components of all of them. The SFI program is a proven instrument to increase the competitiveness of Norwegian industry and this evaluation round has added to the evidence for this. This mid-term evaluation has however highlighted areas which could be improved further and accordingly our recommendations to improve the program and centres are as follows:

Recommendation 1: That RCN encourages SFI centres to work together where appropriate. For example, centres should be encouraged to further develop collaborative associated projects and/or joint PhD student projects or training activities.

Recommendation 2: That SFI takes a more strategic approach to internationalisation by making it a more significant part of proposal assessment and by considering specific initiatives to promote international exchanges for PhD students and early career researchers within the SFI program.

Recommendation 3: That RCN makes it a requirement for the each of the centres to have an International Scientific Advisory Committee (ISAC) and requires that this ISAC meets annually and

prepares a written report that is available to RCN once agreed. This ISAC should be gender balanced and established from the first day of centre funding.

Recommendation 4: That RCN work with the centres to establish ways to enhance the understanding and experience of industry by academically based PhD students.

Recommendation 5: That RCN encourages centres to work with their end user partners to boost the number of industrial PhDs associated with the centres.

Recommendation 6: That RCN, working with the centres, develops a best practice 'tool-box' for centre operation both to improve the performance of current centres and to inspire the development of future centres and directors. This should not impose 'one size fits all' practices on centres or become a set of requirements to be fulfilled in the application process.

Recommendation 7: That RCN formalises exchange of experience between all centres to improve the overall SFI program capacity for knowledge transfer.

Recommendation 8: That RCN requires all centres to report concurrent projects in three categories:

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Recommendation 10: That RCN requires centres to submit PDF versions of their reports in a form where text, apart from in diagrams, is searchable.

Recommendation 11: That RCN ensures that all centres in this evaluation start to seriously address exit planning in 2019.

Recommendation 12: That RCN identifies domains with gender imbalance and invests in specific actions to start a change process with clear goals to accelerate change. Some SFI-Centres could act as role models for the Norwegian research and innovation landscape.

Mattias Lundberg

Alison McKay

Mary O'Kane

David Williams

2 May 2019

BigInsight – Statistics for the knowledge economy

1 Introduction

On 11 March 2019 the evaluation team met with the Chair and members of the Board, the Director, Co-Directors, partner representatives, postdocs, PhD students, and representatives of the host institution, Norsk Regnesentral. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

A strong feature of the Centre is its emphasis on model-based data science. The fact that statistical model building allows uncertainty to be attached to the results is essential to any learning process. Uncertainty quantification is powerful also in indicating where information in data is weak and thus where new data are needed. The Centre's ambition to promote model-based data analyses for both private and public innovations is commendable.

Recommendation 1: That the Centre emphasise more its key capability in model-based data science.

The evaluation team was impressed by the quality of the research performed at the Centre and by the depth and intensity of interaction with its industrial partners, but feels that its international visibility and research output, in terms of high-level publications and software, are not yet commensurate with its actual achievements and its level of innovation as communicated during the interview day. In particular and given the stated goal of addressing outstanding open problems using new methodologies, there should be more opportunities to prepare submissions that would be attractive to the core statistical methods journals and machine learning conferences, thereby raising further the international profile of the Centre and the employability of its graduates. Opportunities to propose and/or organise sessions on relevant topics at major statistical meetings should be taken, maybe in concert with international peers working on related topics.

Recommendation 2: That the Centre increase its volume of publications and the quality of journals in which its work is published. It should also target appropriate high-profile conferences to promote its achievements, for example by proposing, possibly jointly with its international collaborators, special paper sessions on industrial statistics, machine learning and innovation.

The evaluation team finds that focus on partners' innovation needs is an excellent starting point for brain-storming of needs for new methodology and new data. The partner focus remains central across the complete pipeline to implementation of new product/methodology. It seems important, however, to evaluate more systematically the potential generic value of the new products/methodologies (the type of tool, possibly embedded in a larger methods space) and to communicate and document this. Clarifying the path from the specific to the generic would yield longer term value for the Centre.

Recommendation 3: That the Centre seek a more systematic and structured way to extract possible generic techniques from the solutions developed for partner problems and communicate these techniques through publications in high impact journals and widely-available learning materials.

It could be useful for the Centre to engage in the ambitious Norwegian effort to set up a national Health Analysis Platform (HAP) a central entry point for a large number of data sources, including health registries, clinical quality registries, biobanks, and electronic health records, and the analytics that accompany the extraction of knowledge from these data. The project started in 2017 and is currently run by the Directorate for e-Health. It has high political support and partial funding from the NRC. We suggest that the Centre contemplate interaction with HAP. Arguments by the Centre for model-driven data science and for a strong legal and ethical focus in developing analytic tools would be important to this high profile public enterprise, and HAP would provide new avenues for access to a broad range of health data.

3 Internationalisation

The evaluation team agrees that the Centre has excellent international collaborators, in particular STOR-i in Lancaster, the MRC Biostatistics Unit in Cambridge and more recently the Finnish Centre for AI. Its profile is also rising in terms of long term visits from individual scientists with cognate interests.

4 Researcher training and engagement in education

The evaluation team enjoyed its discussion with the student body. In a rather short time the Centre has built a PhD environment that is competitive at the highest level internationally.

The students appreciate the dual cultures of academic statistics/data science and the more specific innovation focus of the partners. While the dual cultures and the need to ‘translate’ the thinking may initially slow down the path to new results, this is outweighed by more efficient working modes once the dialogue is established, and by the clear relevance of the innovation that results from the translation effort.

A special feature of the researcher training at the Centre, in particular in the health domain, is the systematic approach to statistical science as a service. PhD students clearly appreciated encountering a large variety of problems and having the chance to build self-confidence in interacting with partners. The support that students get from seniors when embarking on a consultation project is commendable. Publications for students outside of their thesis topics have resulted from these service collaborations. We suggest that the Centre expands the possibilities for doctoral students to engage in statistical science services to more domains, so that students’ soft skills and employability are further enhanced.

Demand for expertise in statistical data science is expected to increase strongly in all the advanced economies, as the potential for, and added value due to, systematic use of data becomes more evident to companies of all sizes. Some indication of this demand is the fact that the Centre has been unable to pursue some Nærings-PhD possibilities. The evaluation team applauds the stringent entry requirements for the MSc Data Science and agrees that the emphasis on deep conceptual understanding is appropriate. While it appreciates the capacity issues associated with supervision of MSc projects, it views the number of student places on the MSc Data Science as too small in relation to the potential market and in comparison with similar programs abroad. It seems important to increase the number of qualified students who can benefit from the unique opportunity offered by the Centre activities.

Recommendation 4: That the Centre (in conjunction with its research partners) seek to increase substantially the number of industrial PhDs and data science Masters students associated with it.

5 Plans for final three-year period

For the final 3-year period the Centre will continue in line with its 2015 plan in regard to methodologies it is developing. However, the details of the IOs in the 2015 plan have been modified and updated for the next 3-year period especially in the light of better-understood partner requirements and a more realistic approach to available data. And, of course, the IO 'AI – Explanation & Law' introduced in 2018 will continue. Plans for recruitment are appropriate; though even more PhDs, especially more industrial PhDs, and more Masters students are desirable to meet partner longer-term needs for highly trained staff.

Overall the evaluation team assesses the Centre as being on track with its plans for the next three years.

6 Organisation and Management of the Centre

The Centre is well organised and governed with appropriate support from the host institution, Norsk Regnesentral. Under the guidance of the Board (which was well represented at interview by several articulate and committed members), the Centre's Director leads a well-functioning organisation with management tasks shared between the Director and several co-directors.

The Centre has good visibility in Norway and, increasingly, internationally. It has worked hard on good communications externally (in the popular media), internally (Board meetings twice a year; management meetings once a month; BigInsight Days twice a year open to all partners; a regular seminar series organised by the PhD students, etc.) and between the Centre and its partners, something that is much appreciated by the partners who attended the interview.

The partners are highly valued in the Centre, as it is their problems and data that drive the Centre's activities. From the interview and survey it would seem that the end-user partners are generally pleased with the Centre's approach but would like more output in the form of PhD and Masters graduates to hire and research results to translate into in-house improvements.

The Centre has established a good Scientific Advisory Committee (SAC) that has visited the Centre twice so far with its members staying for 3-4 days, providing much valued informal feedback to the researchers. This advice could usefully be formalised further through an annual report which could be shared with all partners and funders and used as a fundamental document in the annual planning process.

Recommendation 5: That the Centre revise the way it works with its Scientific Advisory Committee, requesting that the SAC formalise its advice through an annual report to be shared by all partners and bodies associated with the Centre and used in the annual planning process.

7 Innovation and value creation

The Centre has a well-established and effective process for collaborating with partners to identify and define projects that will create value for industry and/or public sector partners; are feasible in terms of the availability of necessary data; cannot be solved using available approaches/technologies; and have the potential to contribute to the Centre's scientific objectives. Projects are completed within the Centre to Proof of Concept stage and are usually then handed over to the partners for implementation in their organisations. Completed projects are reported through academic publications, project reports and computer code, around 80% of which are open access and published as supplementary material for papers or on open access platforms such as github.

However, a full-itemised list of references to these outputs, including URLs for open access software, was not available.

The Centre has hosted six international researchers through secondments to UiO. Although more would be good, five PhD students had been seconded to user partner organisations and others had made research visits to international universities. The students we met were very positive about their experiences on these, and more widely about the opportunities they had to interact with user organisations.

Recommendation 6: That the Centre find a more effective and comprehensive way of reporting outputs, especially innovation outputs.

8 Funding and financial aspects

All partners make both cash and in-kind contributions to the Centre and provide staff time for the formulation and evaluation of projects in more than one innovation objective area. Researchers in the Centre have secured in excess of 60 MNOK in external funding for associated projects. The partner group is stable and well-balanced with respect to the innovation objectives.

9 Gender aspects

The Centre demonstrated its commitment to gender balance and has initiatives in place, such as not interviewing for posts until at least one female has been shortlisted, to improve this. However, although the gender balance is stronger at higher levels, recruitment of women at lower levels, e.g. to the Masters program (one in 15 in the first cohort), was recognised as an area for concern.

10 Future activities

All Centre partners present at interview believe that the Centre should continue in some form after the end of the RCN financing period. It is possible that it will become part of a new larger initiative. The evaluation team heard that the University of Oslo has planned a major university-wide data science initiative and sees BigInsight as a core part of this endeavour. Norsk Regnesentral is equally keen to maintain the collaboration with the University that has been enabled through BigInsight.

11 Conclusion and recommendations to the centre

The Centre is carrying out very good research that is highly relevant to its partners. It is well supported by its partners and the host institution.

This mid-term evaluation has however highlighted areas that could be improved further, and, accordingly, our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre emphasise more its key capability in model-based data science.

Recommendation 2: That the Centre increase its volume of publications and the quality of journals in which its work is published. It should also target appropriate high-profile conferences to promote its achievements, for example by proposing, possibly jointly with its international collaborators, special paper sessions on industrial statistics, machine learning and innovation.

Recommendation 3: That the Centre seek a more systematic and structured way to extract possible generic techniques from the solutions developed for partner problems and communicate these techniques through publications in high-impact journals and widely-available learning materials.

Recommendation 4: That the Centre (in conjunction with its research partners) seek to increase substantially the number of industrial PhDs and data science Masters students associated with it.

Recommendation 5: That the Centre revise the way it works with its Scientific Advisory Committee, requesting that the SAC formalise its advice through an annual report to be shared by all partners and bodies associated with the Centre and used in the annual planning process.

Recommendation 6: That the Centre find a more effective and comprehensive way of reporting outputs, especially innovation outputs.

Mary O’Kane (Chair)

Anthony Davison

Alison McKay

Juni Palmgren

22 March 2019

Metal Production

1 Introduction

On 6 March 2019 the evaluation team met with the Chair and members of the Executive Committee, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, NTNU. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

The Centre demonstrated clearly that it conducts industry-relevant research in the field of metal production through close collaboration with the industry partners. This conclusion is supported by the generally positive feedback from the industry partners to the survey and active participation of the partners and the Centre researchers in the various Centre and associated projects.

The research activities supported through the Centre were identified through consultation with all partners through a vigorous process including workshops in the lead up to the Centre bid. The research focus and topics are reviewed and adjusted on an ongoing basis to check for relevance in the fast-changing world. The Centre operates with a strong consultative *modus operandi* and, through this, continues to pursue the aim of being industry relevant. There is still some potential to articulate the research priorities in a succinct format. Balancing the criteria of industry relevance and long-term research within a constrained system requires careful management and this was well articulated by the Centre representatives at interview.

The Centre operates with five well-defined research groups. The five research domains are clearly defined and formulated. There is scope to improve communication of the themes of the research activities within what is a very broad scope. There is also potential to improve communication with regard to the criteria used to select specific projects and to evaluate progress towards implementation. It is noted that there is a very good system in place to plan the various research projects, including a well-defined annual planning processes. Criteria to prioritise projects with a generic applicability to the various industry partners have been developed, but these criteria were not formally captured in the documentation provided.

Excellent, world-class research contributions are being generated through the research conducted under the auspices of the Centre as evidenced by the admirable portfolio of scientific publications, conference presentations and quality doctorate and postdoctoral candidates.

The Norwegian industry's unique openness with regard to sharing of benefits around especially safety and environmental research outputs is worth noting as it elevates the socio-economic impact of the research conducted by the Centre. This unique characteristic adds to the value proposition of the Centre. The value-add to Norway (and the rest of the world) from this institutionalised open-access principle is highly commendable.

The Centre through well-established, long-term focussed research activities provides its industry partners with access to world-class engineering and scientific expertise. The industry partners are

encouraging and generally supportive - this is especially observable at the project level. The positive feedback from the doctorate students highlighted that at project level alignment with industry is intentionally sought and implemented and enhances the quality of the graduates produced through the Centre. The willingness of industry to support the research projects indicates that industry partners see value in participating in the research activities.

Researchers from NTNU and SINTEF actively participate in the Centre, and the impact in the host ecosystem is evident through the high number of associated projects. The physical presence of members of the partners at the Centre's premises is a valuable asset to the Centre's operation.

Having a Scientific Committee is excellent in principle and the Centre has attracted four very eminent scientists to sit on this committee. But it appears from the individualised feedback from the committee members in the December 2018 report (the first written report from them) that this valuable resource is not currently used effectively. The feedback from the advisors lacks cohesiveness and will require significant consultation with all partners and stakeholders to turn the advice into an actionable plan.

Recommendation 1: That the Centre revise the way it works with its Scientific Committee, formalising Terms of Reference and bringing the Committee together to provide its advice as a single body rather than a collection of four individuals. In particular, the Centre should ask the Committee to provide a consolidated opinion from the four individual pieces of advice provided in December 2018 and it should then have the Committee meet together at least once a year and provide a single annual report.

Also, there is still a need to demonstrate the impact of the research activities and the progress of projects to implementation.

3 Internationalisation

The Centre engages in international research cooperation through different schemes such as INTPART, EIT Raw Materials, and bilateral cooperation with top-level universities. It acts as a very successful flywheel for international collaboration as illustrated by an impressive number of associated projects in the EU's Framework Programme. It is very active in organising international workshops and conferences in the Metal Production field, bringing together academia and industry. Its Scientific Committee consists of high-level scientists who bring valuable feedback and recommendations to the Centre's research programme. The Centre receives visits from international early-stage and experienced researchers and Centre researchers participate regularly in international conferences and spend research stays in international excellence centres.

4 Researcher training and engagement in education

The evaluation team found that the Centre - in cooperation with the Metal Processing group of NTNU - has put in place an excellent system to inform potential students of the metal production field. These efforts have led to an increasing number of students in the field at NTNU which is remarkable as the opposite is the global trend. The 14 PhD students are a very good mix between home-grown and international talent. The Centre values diversity and this emphasis is evident in the composition of the student team. Together with the 12 PhD students involved in the associated projects and the Centre's postdocs, they form a reinforcing student community both at the research and social levels. The Centre graduates 10 MSc students annually, most of whom join Centre partners after graduation.

The Centre helps in setting up course modules at the Masters level with participation from partners both as students and teachers.

Each of the student projects is supported by a reference group comprised of members drawn from the Centre's partners. The students praised this system for its responsiveness to their research needs and as an expert sounding board in general. The Centre draws on the University's graduate coursework offerings for general skill training such as communication skills and IP issues.

5 Plans for final three-year period

The Centre is clear about how it intends to finalise its research plan for the remaining period. The work will be based on the ongoing research projects but the Centre will address the recommendations of the Scientific Committee and translate these recommendations into modifications to the current research activities and research organisation.

The Centre will also commence a system of yearly visits to each of its partners to support the ongoing activities and to understand their research interests better. There is one remaining PhD position that needs to be filled.

6 Organisation and Management of the Centre

The Centre has effective governance and good management led by a dedicated and popular Director. Representatives from both industry and research partners are involved in the Centre's governance and advisory structures, serving on the Executive Committee and the reference committees for the research programs and the PhD students. The partner representatives also attend the Centre's various workshops and special meetings.

The Scientific Committee has been created to provide high-level advice to the Centre. As noted above, the effectiveness of this Scientific Committee will be enhanced by having it meet face to face as opposed to just asking for opinions from each of the members.

The evaluation team heard several times about the detailed workshop and consultation processes that led to the development of the original proposal for the Centre. This included a detailed research plan for the life of the Centre that has been revised annually in consultation with partners. Quite appropriately, the original research plan has become more streamlined over time as the Centre realised its original plan was overly ambitious and not sufficiently focused to achieve research excellence.

NTNU as the host institution for the Centre has provided good support including recently appointing an Innovation Manager to assist the discipline of metal production with commercialisation and attraction of major research funds.

One area that could be significantly improved however is communication. The evaluation team noted that the Centre is overly modest in describing its achievements and impact. For example, the Centre representatives were unable to describe succinctly the core research proposition for the Centre. This is disappointing as it is clear the Centre has a good story to tell and should tell it well to benefit itself and its partners and to attract further funding to secure its future.

Recommendation 2: That the Centre review its approach to communications with the aim of communicating internally and externally much more effectively than at present. This includes developing a clear and succinct articulation of its core research rationale; working out how to 'tell the Centre story', capturing its notable achievements, processes and impact on partners; and improving

communication between the Centre and each of its partners. To be effective in communications the Centre will need, at the very least, a communications strategy to be implemented by an appropriately experienced Communications Manager who should be appointed as a matter of urgency.

7 Innovation and value creation

The Centre covers the Norwegian industry value chain from raw materials to aluminium, titanium oxide, silicon/FeSi and FeMn/SiMn (aluminium, silicon and ferroalloys). There are 9 industrial partners.

Together with its three research organisations, the Centre has built a critical mass of researchers to secure knowledge transfer for the partner needs, both in the short and long term. The Centre has also demonstrated that a substantial part of its knowledge creation can be further developed in associated projects carried with or without Centre partners. In addition to this, the Centre secures value creation through activities such as the following:

- mutual mobility of people between industry and academia, e.g. PhD visits to industry and industry being appointed as adjunct university staff
- reference groups which function as meeting places for industry and academics, especially the PhD students
- co-publication between industry and academia.

According to the self-evaluation report, most partners are very satisfied. All partners have clear goals that they want to achieve through participation in the Centre. However there are some partners that seem disappointed with the outcomes from the Centre so far. It will be very important for Centre management to set expectations with these partners about likely industrial and scientific impact for the final three years.

The list of innovations and basis for future innovations from the Centre is commendable. The evaluation team suggests that the Centre could make more of this output and impact on industry (see Recommendation 2 above). We encourage the Centre to present the total impact on industry in a more cohesive, structured, distinct and attractive way to make the Centre even more visible internally and for the international community.

As noted above, NTNU has recently introduced innovation managers and appointed one to work with the discipline of metal production. The Centre will have access to this resource. Unfortunately, it is still very unclear how this person will interact with the Centre. The evaluation team suggests the Centre and its Executive Committee clarify this; and all partners in the Centre must be informed of this new resource.

Recommendation 3: That the Centre in close cooperation with its partners work out how to leverage the appointment of an NTNU innovation manager dedicated to the field of metal production and decide how to embed this innovation manager appropriately in the Centre's organisational structure.

8 Funding and financial aspects

The Centre has a good balance of cash and in kind from its partners. We note that the Centre in-kind contributions from the partners to date have been higher than in the budget. If the associated

projects originating directly and indirectly from the Centre are also taken into account, the total turnover is very impressive.

9 Gender aspects

The Centre is very successful in working with equal opportunity. The gender balance at all levels of the Centre is noteworthy.

10 Future activities

The Centre explained that it proposed to continue in some form after the end of the RCN financing period. For some time it has been successfully building up a portfolio of associated projects to sustain the research effort beyond the SFI centre funding. But it has not yet enunciated the form this post-SFI organisation will take. While building up the funding is laudable, a core rationale and focus of the new entity is lacking, as is a description of how it will add value to its participants.

Recommendation 4: That the Centre more intentionally and strategically plan for its future post RCN funding.

11 Conclusion and recommendations to the Centre

The Centre is carrying out excellent research in an economically important field. It is well supported by its partners and the host institution.

This mid-term evaluation has however highlighted areas, which could be improved further, and, accordingly, our recommendations to improve the Centre are as follows:

Recommendation 1: That the Centre revise the way it works with its Scientific Committee, formalising Terms of Reference and bringing the Committee together to provide its advice as a single body rather than a collection of four individuals. In particular, the Centre should ask the Committee to provide a consolidated opinion from the four individual pieces of advice provided in December 2018 and it should then have the Committee meet together at least once a year and provide a single annual report.

Recommendation 2: That the Centre review its approach to communications with the aim of communicating internally and externally much more effectively than at present. This includes developing a clear and succinct articulation of its core research rationale; working out how to 'tell the Centre story', capturing its notable achievements, processes and impact on partners; and improving communication between the Centre and each of its partners. To be effective in communications the Centre will need, at the very least, a communications strategy to be implemented by an appropriately experienced Communications Manager who should be appointed as a matter of urgency.

Recommendation 3: That the Centre in close cooperation with its partners work out how to leverage the appointment of an NTNU innovation manager dedicated to the field of metal production and decide how to embed this innovation manager appropriately in the Centre's organisational structure.

Recommendation 4: That the Centre more intentionally and strategically plan for its future post RCN funding.

Mary O’Kane (Chair)

Bart Blanpain

Isabel Geldenhuys

Mattias Lundberg

25 March 2019

C3 – Centre for Connected Care

1 Introduction

On 12 March 2019 the evaluation team met with the Chair and members of the Board, the Director, research leaders, partner representatives, postdocs, PhD students, and representatives of the host institution, Oslo University Hospital. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

On the basis of the submitted documentation, the evaluation team found it hard to gain a clear impression of C3's overall program of work. It found the categorization of work packages and projects confusing, especially since some WPs appeared to be rather broad cross-cutting activities and others were more focused research projects. Following discussion with the Centre, the structure of its research program became clearer.

The WPs draw on a number of partner-led cases, comprising different forms of healthcare innovation, all with the over-arching aim of promoting patient-centric care. The WPs embrace a range of themes, including data infrastructure, simulation and modelling, procurement and remote care. While the evaluation team does not question the scope of these WPs, it is noted that there is considerable variation in the scale of activity and the extent to which this work has the potential to be internationally leading. In some cases, the WPs seem rather under-resourced (e.g., WP10) and in other cases the WP is essentially a review of existing research (e.g., WP5).

At this stage, it was felt that none of the WPs were conducting work at an internationally-leading level, nor were any research breakthroughs identified. However, there are areas of research that show promise. The evaluation team felt that the work on simulation and modelling could develop into an important methodological support for rapid testing of innovative solutions to understand their potential impact and scale-up implications. Connected to this is the WP on health value (WP10), focusing on early-stage evaluation as a support for scaling-up. The team was also impressed by the emerging work on procurement models for innovation (WP9). More generally the evaluation team welcomes the ambition of C3 on co-creation of care and treatment, and the need for test-beds for testing and developing new models of care that involve radical changes in its organisation and transfer of power from professionals to patients. The project on "embedded design" is therefore very interesting although results have not been published yet.

The evaluation team recognises that the Centre is at a relatively early stage, however the team also felt that the range and volume of research outputs is rather limited. The focus seems to have been on chapters in books and conference papers. While a range of papers in peer reviewed journals have been published in specialist journals, C3's research has yet to be published in leading technology and innovation management, business, and health services/policy journals.

The most important publications listed in the self-report include three conference papers, three book chapters and eight articles (three in non-indexed journals); the journal impact factors vary between

1.8 and 8.1. The paper in the highest ranked journal deals with stroke incidence from the Norwegian hospital registry.

The evaluation team notes that while a stated goal of C3 is to help accelerate the adoption and diffusion of patient-centric connected care innovations, this is not always evident in the publications output. It was felt that researchers might develop the work begun in WP1 on scenarios for future health as a way of refining the Centre's definition of patient-centric connected care and using this to guide future research outputs. The team also felt that it will be very important to create partnerships with patient organisations in order to help identify relevant research questions from the patients' perspectives, given the stated aim of focusing on patient centricity and patient representation.

The international visibility of the Centre is currently low. It will be important to ensure that steps are taken to raise the visibility of C3, to help encourage groups from outside Norway to collaborate on research and other activities and attract visiting researchers. Benchmarking C3 against other similar research centres might be a useful exercise.

The Centre is already interdisciplinary, but the team felt it will be important to involve other disciplines and additional research methods in the future development and conduct of its research projects. This will especially be the case if C3 aims to focus on a smaller number or high impact research activities in the future. Expanding the range of disciplines and methodologies might involve recruiting new researchers by means of open calls or approaching individuals known to have competence needed.

Recommendation 1: That the Centre focuses its research around a smaller number of high impact end user-led projects that have clear performance/success criteria. In doing this the Centre should draw on a wider range of methodologies that will enrich the gathering of evidence of impact.

Recommendation 2: That the Centre defines clear measures of success for research, research training, and impact. This should capture the influence of C3 on its end user partners and other stakeholders, and the wider healthcare system.

Recommendation 3: That the Centre reviews its WP structure to focus on a smaller number of scientific challenges that were identified in the interview, including forming a consensus within the Centre on the term "patient-centric care", selecting a wider range of simulation methods and ensuring critical mass of researchers and leaders within each WP area.

3 Internationalisation

The team welcome the emerging range of international research partners working with C3, including IKON/ Warwick University, UK, the Helix Lab and Nesta Health Lab in London, and the Centre for Innovation at Mayo Clinic. There were some concerns, however, about the collaborations in China and India. In particular, the energy and time spent realising such collaborations and achieving concrete research results needs to be weighed against the benefits. The evaluation team was also concerned to ensure that the activities in China generate meaningful data that can be used to draw lessons for the Norway context.

4 Researcher training and engagement in education

A number of PhD students met with the evaluation team. Several of the WPs rely on the work of PhD students, which seems to be very stimulating for them. All the students expressed satisfaction with the overall level of training and support. Some of the students from other countries reported that

the existence of the Centre had been crucial for them to be able to perform their project. The Centre could consider opening up towards further collaboration with other similar centres or research groups abroad, such as PhD courses.

The evaluation team welcomes the steps taken by C3 to translate lessons learnt from its research into Masters' courses and executive education. This should be an effective way of ensuring dissemination and take-up of C3's work within Norway's healthcare ecosystem.

5 Plans for final three-year period

As reflected in earlier recommendations, the Centre has decided to focus on a smaller number of higher impact innovation projects. This is to be commended. However, although the Centre identifies health challenges to focus on for the final three year period in the report, these were not explicitly linked to the innovation projects and the overall impression from the interview was that the Centre was still considering which of a longer list of innovation projects to focus on.

6 Organisation and Management of the Centre

As outlined earlier, the Centre is in transition from its first stage, where the emphasis of its activities focused on understanding the needs of multiple stakeholders, to its second stage where the focus will be more on the underpinning science. In the first stage, a leader with first-hand experience of healthcare innovation was necessary but, in this second phase, leadership from a recognised research leader will be critical to the Centre's success.

As recognised in the current management structure and at the interview, effective communication with all stakeholder groups will require a more nuanced approach where different communication methods are used for different groups. A particular effort will be necessary to communicate implications of the Centre's scientific findings to policy makers and decision makers, ideally by a person with wide experience of healthcare innovation.

At the interview the evaluation team learnt that the Board had instigated a review of the Centre's organisation and governance structures and that this had resulted in a revised structure that will be better equipped to respond to the needs of the final four years where the Centre's activities will have a stronger focus on the underlying science. However, the roles and success criteria for the groups within this structure were not always clear and, from the discussion with PhD students and postdocs, there is no forum within which these early career researchers meet with each other without members of the leadership team. In addition to Recommendation 5, it is suggested that forming such a forum would improve communication across work packages and innovation projects within the Centre.

The Centre has a Strategic Advisory Committee that met twice in 2018. Two of the three members are Norwegian. In its second stage, the Centre's research will benefit from exposure to a wider advisory group that includes international perspectives and is gender balanced. In addition, with the focus on core scientific priorities, a refreshed advisory group, covering all priority areas would be beneficial, as would a written report (at least one per year) that includes comments on both strengths and opportunities for improvement.

The Centre has a clear visual identity in its annual reports and posters but its web presence is confusing with web search engines finding multiple versions of its web site.

Recommendation 4: That the Centre, to deliver its new, more focussed research direction, promote the research director to the role of Centre Director and the current CEO join the Board and have a co-director role with a focus on promotion and policy matters.

Recommendation 5: That the Centre defines terms of reference and clear success criteria for each of the groups in the governance and management structure.

Recommendation 6: That the Centre revises its Strategic Advisory Committee, increasing the number of eminent international experts and ensuring the Committee is gender balanced. The Strategic Advisory Committee should meet annually and formalise its advice through an annual written report which can be shared across all partners and bodies associated with the Centre and used as a useful input to the annual planning process.

Recommendation 7: That the Centre develops a communications strategy that includes its web presence and covers the needs of all stakeholders.

7 Innovation and value creation

The Centre focuses on innovation in three ways:

- a) innovation arising from its research activities;
- b) studies on what enables innovation in healthcare (meta-innovation studies); and
- c) through the Centre acting as a meeting place/centre of expertise on how end-user partners from the public and private sectors deal with barriers (regulation, policy, guidelines, procurement, etc.) to uptake of healthcare innovation in processes, products and systems.

At the moment there are no strong examples of end-user partners adopting innovation arising from Centre research activities and using them for in-house improvements. This should change soon as several PhD theses in the Centre are finalised.

At interview the example the Centre (including its industry partners) cited most often of its research on what enables innovation in healthcare was the major study on procurement being carried out by Centre researchers from the Business School. This research, embedded in a study on wider aspects of public sector procurement, has the potential to have considerable impact on the Norwegian healthcare system.

Public and private sector end-user partners present at interview were all enthusiastic about the value to them of the Centre acting as a meeting place/centre of expertise on how to deal with barriers to uptake of healthcare innovation. Several detailed examples were provided including the credibility that the company Dignio derives in its activities in China from having Centre researchers as part of its team there interacting with high prestige organisations in the Chinese healthcare system.

This tripartite focus on innovation is appropriate for a Centre such as this but it should be augmented by formal methods to assess/measure the Centre's contribution to impact under each of these three forms of innovation. (See Recommendation 1)

One of the most impressive examples of current impact from the Centre is in education and training especially through Centre material being used as case studies in Masters' courses on innovation for health user professionals.

8 Funding and financial aspects

The evaluation team notes that the Centre had no cash contribution from the user partners. This has severely limited the Centre's capacity to explore new and promising lines of research. We do note, however, that the Centre has recognised the need to raise funds for major new initiatives, effectively through associated projects.

Given that unconstrained cash in the Centre is tight, the evaluation team was surprised to note the high administrative overhead of the Centre (with the Director plus 2.65 FTE administrative staff paid for by Centre funds). We suggest this be scaled back in order to free funds for core activities in the upcoming research-intensive stage.

9 Gender aspects

The gender balance of the Centre is good in all research teams and management structures. Only the Strategic Advisory Committee needs attention in this regard (see Recommendation 6).

10 Future activities

Plans for continuation of Centre activities were not well-formed and depend on developments in the final three years. However, the end user partners expressed confidence that learning from the Centre's activities would have a longer term impact.

11 Conclusion and recommendations to the centre

The evaluation team was concerned by the report sent to it ahead of the evaluation interview. The description of the Centre's core research proposition and of its activities more broadly were difficult to understand. This was exacerbated by the document being presented as a largely unsearchable pdf image file. The interview clarified many points but it is clear the Centre needs to improve its communication.

As a competence centre supporting a complex but societally important area, a core strength of the Centre lies in the commitment of its partners who have worked hard to support the development of a programme of activities for the first stage. This has allowed the Centre to deepen its understanding of stakeholder needs and so identify key scientific areas that need to be addressed. The challenge for the second stage will be to deliver scientific advances in these areas and high impact in the healthcare sector.

This mid-term evaluation has highlighted areas which could be improved and accordingly our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre focuses its research around a smaller number of high impact end user-led projects that have clear performance/success criteria. In doing this the Centre should draw on a wider range of methodologies that will enrich the gathering of evidence of impact.

Recommendation 2: That the Centre defines clear measures of success for research, research training, and impact. This should capture the influence of C3 on its end user partners and other stakeholders, and the wider healthcare system.

Recommendation 3: That the Centre reviews its WP structure to focus on a smaller number of scientific challenges that were identified in the interview, including forming a consensus within the

Centre on the term patient-centric care, selecting a wider range of simulation methods and ensuring critical mass of researchers and leaders within each WP area.

Recommendation 4: That the Centre, to deliver its new, more focussed research direction, promote the research director to the role of Centre Director and the current CEO join the Board and have a co-director role with a focus on promotion and policy matters.

Recommendation 5: That the Centre defines terms of reference and clear success criteria for each of the groups in the governance and management structure.

Recommendation 6: That the Centre revises its Strategic Advisory Committee, increasing the number of eminent international experts and ensuring the Committee is gender balanced. The Strategic Advisory Committee should meet annually and formalise its advice through an annual written report which can be shared across all partners and bodies associated with the Centre and used as a useful input to the annual planning process.

Recommendation 7: That the Centre develops a communications strategy that includes its web presence and covers the needs of all stakeholders.

Alison McKay (Chair)

James Barlow

Inger Ekman

Mary O’Kane

26 March 2019

EXPOSED – Exposed Aquaculture Operations

1 Introduction

On 4 March 2019 the evaluation team met with members of the Board, the Director, project leaders, PhD students, post-docs, representatives of the host institution, and some representatives of the industry partners (though unfortunately only a small number). In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

It was clear from the thoughtful material presented at interview that the Board and management of the Centre had used the mid-term evaluation to reflect effectively on what had and what had not worked well and, on the basis of this assessment, were planning for the next three years and, in a limited way, beyond.

2 Research activities

The Centre benefits from an excellent competence profile within the research teams responsible for research areas 1 to 6.

The research leaders are each resident within larger groupings of suitable critical mass, however the Centre budget constrains overall access to resources. The participants have nonetheless evolved practical approaches to retain good research outputs despite this constraint. Ongoing prioritisation will be needed during the final phase to avoid spreading resources too thinly.

The research program is diverse and ambitious, as befits the challenges of farming fish in exposed marine environments, where existing technologies are suboptimal/unsuitable. The associated scientific approaches and project goals range from routine to cutting edge and it remains to be seen which of these will yield the most practical benefit (e.g. coastal surveys versus automated inspection technologies).

The evaluation team supports the mid-term redirection of research activities towards demonstrations and practical innovation opportunities.

Long-term industrial research in the field outlined in the project description

The Centre was founded upon successful prior collaborative R&D relationships, which have been enlarged and diversified to meet the specific needs of stakeholders engaged in fish farming in exposed environments. As such, the participants have already displayed capacity for long-term industrial research and the need for this will extend beyond the 8-year lifespan of the Centre, not least of all to exploit development licences.

Scientific publications (including co-publications with user partners) and papers at recognised international conferences

The number and scope of publications and conference papers are seen as being at a good level considering the lifespan of the Centre. The most recent list of manuscripts in preparation/submitted provides reassurance that the number and quality of scientific outputs is on upward trajectory, as

benefits the goals of the SFI program. All participants are encouraged to contribute substantively to publishing and presenting papers, ensuring that the Centre gets credit for its research achievements.

Research profile and international visibility

The individual teams responsible for the research areas have been building their profiles positively, however the enabling role of the Centre is not projected consistently. This probably reflects the finite lifespan of the Centre. Nonetheless, all partners should contribute to raising the profile of the Centre throughout its duration.

The Centre has decided not to include an international scientific panel as part of its organisation. The reasoning for this has been presented and accepted by the evaluation team, nonetheless the lost opportunity in terms of international visibility should be recognised and alternative opportunities sought (see Section 3, Internationalisation).

3 Internationalisation

International research cooperation, e.g. EU's Framework programme

The project participants have been actively involved in international consortia for proposal writing to the EC, until now without success. The evaluation team acknowledges that competition for funding through these agencies is very high. The plan to continue competing in such programs is supported by the evaluation team, along with measures to influence the future direction of calls for proposals, e.g. via EATiP. It should be noted that being a part of EC programmes should also be seen as important networking activities. Therefore, even minor participation in consortia would be good and quite useful.

Collaboration with international research groups

The Centre provided an honest status report on expected versus actual international collaborations as part of the midterm self-evaluation. The evaluation team views the collaborative link with Fiskaaling/Faroes as being very relevant and in line with the unfulfilled expectations of industry partners who are producing salmon in conventional circular cages. Looking ahead, the Centre has identified scope for further productive international collaborations, in regions that offer export opportunities for industry members and where learning could be brought back to Norway. The evaluation team supports this aspiration, resources permitting.

Foreign senior researchers, postdocs and PhD students in the centre and outgoing

As NTNU, IMR and SINTEF are highly international institutions, it has not been difficult to attract foreign staff.

Recommendation 1: That the Centre increase its visibility for example by hosting an international conference on state of the art of exposed marine aquaculture (aligned with AquaNor 2021), to include published conference proceedings. This could incorporate an invitational workshop of experts and practitioners, to define knowledge gaps and act as a roadmap for further work.

4 Researcher training and engagement in education

The PhD students are closely connected to NTNU, IMR and partly to SINTEF. The progress of the PhD studies is in safe hands within this experienced PhD school. The projects are related to EXPOSED, but are mainly defined by the supervisors/PhD students at NTNU, IMR and SINTEF. Some relationships to the industrial partners exist; typically in connection with field work. External stays are not mandatory

and not used to a significant extent, and therefore the external stays do not serve as an instrument for international networking.

Engagement in education on Masters and PhD levels

A substantial number of MSc students have been engaging with the Centre, mainly through their supervisor at NTNU. It has been less common for the industry to actively participate in the definition of MSc projects.

Recommendation 2: That the Centre ensure that its directly-financed PhDs are better connected to and integrated into its overall activities. This includes tighter interaction with the end-user partners, including the option for industry partners to act as co-supervisors. Regular face-to-face interactions among directly-financed PhDs would be beneficial, including co-location where possible within the different Centre sites. Coordinated engagement in the NTNU Ocean School of Innovation would help towards this, as would calling on the students to help deliver knowledge exchange events.

5 Plans for final three-year period

The Centre outlined how it intends in the final three-year period to focus more on demonstrator projects and to be more agile in addressing industry partner innovation needs. The self evaluation played an important role in identifying the need for more focus on innovation and demonstration, which is positively acknowledged by the evaluation team.

To maximise the chances of success, this will require detailed planning throughout the final phase, with annual reviews and adjustments. As part of this, the description of future projects should adhere to clear and good project standards.

For shorter-term projects, there is scope to engage dedicated and focused Masters projects, which would enable closer interaction between students and industry partners (see section 4, above).

Recommendation 3: That the Centre construct a more detailed work plan for 2019 and the subsequent three years and then carry out clear annual assessments and reviews of milestones both those dedicated to research outputs and those addressing knowledge transfer to industry. The annual update should be flexible and communicated to all partners. Ideally this process should also take into account external influences, e.g. new governmental policies or research breakthroughs.

The evaluation team notes that while the Centre is increasing the direct focus on industry problems, this is unlikely to be fully appreciated unless the industry partners move from what appears in many (though certainly not all) cases to be a relatively passive involvement in the Centre and take a more active role in the Centre and its projects.

Recommendation 4: That the Centre's industry partners be more proactive in raising questions concerning innovation, regulation/policy issues, and research. In particular the end-user partners need to articulate the desired potential impact of each project in a more structured way.

One of the most important contributions of the Centre to date has been its enunciation of the major research challenges facing the successful development of marine fish farming in exposed sea locations. This process highlights that addressing these challenges is a bigger task than can be solved by the Centre working alone. However the Centre is well networked and could leverage its connections to find third parties who could solve or could contribute to solving these challenges for industry. In other words, the Centre could become an important research broker in this economically-important emerging field.

Recommendation 5: That the Centre build on its evolving detailed understanding and specification of the major research challenges facing marine fish farming in exposed sea locations to provide industry with a way forward to finding rapid solutions to major roadblock problems, either through the Centre activities directly or through brokering solutions through third party providers.

This new field will be strengthened by development of supportive government policies and appropriate regulation. At interview the Centre provided an example of government interest in how the Centre could help with these matters. The evaluation team agrees this is a good role for the Centre and provides visibility and possibly future funding.

Recommendation 6: That the Centre articulate its position on what industry requires and what new knowledge has been gained to help develop appropriate government policy and regulation.

6 Organisation and Management of the Centre

The Centre is fortunate to have a dedicated board and an excellent director who leads the Centre with the support of a small team and limited funding for administrative matters.

The limited administrative resources available mean that matters such as communication are good but could be better. While it is probably too late to require industry partners to increase their cash contributions to the Centre, it is important that the Centre prioritise its administrative activities for best effect. Thus, the team encourages the Centre to develop further its support for PhD students (see Recommendation 2 above), increase its international visibility (see Recommendation 1), and continue to develop the impressive EXPOSED catalogue which provides an excellent resource for Centre partners on what has been achieved in the Centre to date.

The Centre has also done well in managing internal communication and focused discussion on core research problems through the EXPOSED Days, held twice a year. These were praised by industry and research partners and by PhD students. They certainly should be continued in the next three years.

Another effective communication tool was the workshops held on topics such as safety and attended by field operators from the industry partners. These too were highly appreciated by all partners that had sent representatives.

The host institution, SINTEF, provides good support to the Centre particularly through the personnel and scientific infrastructure it makes available. As well, it is clearly proud to host the Centre.

7 Innovation and value creation

The Centre has covered most parts of the value chain for marine fish farming in exposed sea locations. It has 16 user partners divided into 4 main industrial groups: fish farmers/end-users of technology and solutions; technology/solution providers; service providers; and engineering and certification. Those partners' needs are organised as five key research challenges. We commend the Centre and its partners for the mutual knowledge transfer aiming to find both long- and short-term solutions for industry.

However, the numbers of partners in combination with large number of well-motivated research projects poses a significant challenge for the Centre to secure visible and tangible impact for industry. The Centre has taken steps to address this, e.g. through starting several demonstration projects, and through associated projects originating in the Centre and also verification projects. We suggest that the Centre could report the verification projects in a more structured way to maximise their impact.

From the self-evaluation documents there is an impression that industry is split in its opinion as to the extent it has secured impact from the Centre. The evaluation team suggests that the industry needs to be more proactive raising questions concerning innovation, regulations/policy issues and research. For example, the new EXPOSED Catalogue reports a diversity of outputs that can be used to map which innovations, verifications or demonstrations are explicitly used by industry partners. (See Recommendation 4 above.)

The evaluation team also encourages the Board and management to look into the evaluations from the user partners to identify and secure impact from the Centre for each partner.

Industry partners are involved in the steering committee of each project. In addition, as noted above, there is good interaction during workshops and Exposed days between researchers including PhDs and user partners. This seems to be the main interaction between industry and PhD students. The evaluation team suggests that the PhD cohort would benefit from coordinated site visits to producers and participating supply chain companies.

8 Funding and financial aspects

The evaluation team notes that the Centre has very limited cash contributions from the user partners. This has severely limited the Centre's capacity to explore new and promising lines of research.

9 Gender aspects

The gender balance in the Centre can improve though we commend the Centre and its partners for the awareness of equal opportunity issues. We also note the good specific actions taken by NTNU to improve gender balance. We understand that the Centre has not had the capacity to put specific effort into this issue. The host institution might consider helping the Centre improve its profile with respect to this issue for the future.

10 Future activities

At the moment the Centre does not have concrete plans for continuation of its activities after the end of the RCN financing period. However, if the Centre implements the recommendations for the next three years (given in Section 5 above), the evaluation team believes it will be in a good position to attract funding to move to a new phase of research to continue to support this important emerging industry.

11 Conclusion and recommendations to the Centre

As a competence centre supporting an economically important emerging industry field, the Centre is performing well especially given the diverse array of industry partners and the absence of cash from industry partners.

This mid-term evaluation has however highlighted areas which could be improved and, accordingly, our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre increase its visibility for example by hosting an international conference on state of the art of exposed marine aquaculture (aligned with AquaNor 2021), to include published conference proceedings. This could incorporate an invitational workshop of experts and practitioners, to define knowledge gaps and act as a roadmap for further work.

Recommendation 2: That the Centre ensure that its directly-financed PhDs are better connected to and integrated into its overall activities. This includes tighter interaction with the end-user partners, including the option for industry partners to act as co-supervisors. Regular face-to-face interactions among directly-financed PhDs would be beneficial, including co-location where possible within the different Centre sites. Coordinated engagement in the NTNU Ocean School of Innovation would help towards this, as would calling on the students to help deliver knowledge exchange events.

Recommendation 3: That the Centre construct a more detailed work plan for 2019 and the subsequent three years and then carry out clear annual assessments and reviews of milestones both those dedicated to research outputs and those addressing knowledge transfer to industry. The annual update should be flexible and communicated to all partners. Ideally this process should also take into account external influences, e.g. new governmental policies or research breakthroughs.

Recommendation 4: That the Centre's industry partners be more proactive in raising questions concerning innovation, regulation/policy issues, and research. In particular the end-user partners need to articulate the desired potential impact of each project in a more structured way.

Recommendation 5: That the Centre build on its evolving detailed understanding and specification of the major research challenges facing marine fish farming in exposed sea locations to provide industry with a way forward to finding rapid solutions to major roadblock problems, either through the Centre activities directly or through brokering solutions through third party providers.

Recommendation 6: That the Centre articulate its position on what industry requires and what new knowledge has been gained to help develop appropriate government policy and regulation.

Mary O'Kane (Chair)

Erik Damgaard Christensen

Mattias Lundberg

Robin Shields

14 March 2019

Foods of Norway

1 Introduction

On 19 March 2019 the evaluation team met with the Chair and members of the Board, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, NMBU. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

It should be noted that one of the evaluation team, Kristiina Kruus, had recently begun a collaboration (February 2019) with one of the Centre Workpackage leads, but this was not judged to be a conflict of interest.

2 Research activities

The aim of Foods of Norway is to feed fish and farm animals using sustainable new ingredients. The goals are particularly relevant considering the state of the art and the rapid advancement of science in the field. The centre has a very ambitious research plan, which aims to address the whole value chain from biomass to fermentable sugars and feed ingredients. The plan also includes substantial amounts of animal testing to prove the effects of the ingredients. Some of the tasks have been shifted from the academic teams to industrial partners for valid reasons (for instance much of the work on scalability). The collaboration with industry is very strong and this centre is to be complimented on this.

The work remains sufficiently focussed on its initial objectives, but the evaluation team feels that greater attention must be given to chemical characterisation of the products and particularly scale-up of yeast production for necessary animal testing. It is suggested that the Centre should seek collaboration with other research groups with necessary expertise.

The Centre has been working on a number of raw materials including wood biomass, grass and seaweed. The biomasses represent abundant Norwegian biomasses and are thus clearly justified. However, due to sustainability issues, it should be emphasized in communication that only side-streams from the forest industry are being used. In order to make real impact, the Centre is highly recommended to focus on one or two biomasses in the coming years. Including new raw materials to the research agenda should be carefully thought through.

A clear pipeline between WP1 to WP 6 needs to be established. It would be expected that one or two products developed in WP1, WP2 and WP3, would continue through the pipeline of work packages WP 4, 5 and 6. The later WPs are perhaps too dependent on the work of industrial partners. It is advisable that the centre focusses on yeast production, seaweed applications and feed efficiency in fish in the next five years rather than diluting its work with a large number of smaller projects (insects, barley spelt grains). It was difficult for the team to see where feed efficiency in swine and cattle fits in the centre based upon the data presented.

Unfortunately, the centre failed to clearly present the depth of their scientific excellence in the reports and power point presentations. However, during the discussions the following unique scientific achievements were identified

- Fractionation of seaweed, a relatively less studied renewable biomass source, which is particularly abundant in Norway.
- Novel enzymes for breakdown of seaweed carbohydrates have been discovered and a fractionation process developed, which provides high purity laminaran for example.
- Unique high protein content yeast strains have been developed.

The centre could set itself more ambitious scientific aims for its future work and should ensure that this is hypothesis driven as appropriate. Many of the WP leaders and senior scientists have distinguished international reputations, consequently a high level of scientific ambition should be expected.

In addition, the following technological developments have been achieved:

- using side-streams from slaughterhouses as a nitrogen source in yeast production
- up-scaling yeast production to a 200 litres scale with an industrial partner
- delivering yeast material for trials with salmon and piglets

Techno-economic assessment and LCA need to be included in the research. While the industrial partners involved in the centre are clearly doing such analyses, it is of utmost importance that the new process concepts coming from the centre are analysed in terms of their economic and technical feasibility very early in any development work.

The team is well-known in the field and has complementary experience. The different expertise represented among the work package leaders, including enzymology, metabolomics, animal nutrition, metagenomics, and meat quality are well suited to this complex and challenging programme of work. No other international group focusses so intensively on the application of yeast diets for feeding animals. It is advised that the IP developed in the centre is carefully protected, particularly if there is an ambition to sustain the centre long term. The work package leaders have excellent external presentation and publication records. However, with respect to the current Centre, a higher number of publications might be expected. It is recognised by the review team that many publications are in preparation. Unfortunately, no targets were set for publications in the original research plan. It is highly recommended that the Centre make publication output a KPI for the upcoming period to reflect their aspirations to international leadership.

The following areas were identified as areas of focus as the project continues; scalability of the yeast process, full chemical characterization of the products, economic assessment, in vivo activity of selected products and testing of mode of action at a larger scale. Feed and food regulatory issues must also be addressed before commercialisation of products, the team should consider addressing current research questions (product characterisation, chemical safety) in this respect.

Recommendation 1: The Centre should set itself publication targets reflecting its aspirations and potential to be a world leading centre in its field.

Recommendation 2: Discussions identified that communications could be improved within the Centre to both enhance the understanding of individual researchers of the overall aim and objectives

of the centre and to improve coherence within each work package and across the work packages. This could be achieved either “top-down” or by appropriately resourced “bottom-up” activity led by the Research Assistants and PhD students.

Recommendation 3: As the Centre Task Force considers the routes for the commercialisation and scale-up of its yeast technology it should consider what additional capabilities may be required in biochemical engineering and for large scale animal work. The Centre should also consider the structure of Work package 6 so that it both retains and deepens its core capability in LCA and expands upon it to embrace the broader business and economic issues associated with the commercialisation of the Centre technologies.

3 Internationalisation

The work package leaders have a good network of collaborators across the world (Europe, USA, Chile and Australia). The Centre has chosen their collaborations well and all collaborations complement their research plans. The work package leaders are involved in responding to major national and international calls (including Cost actions and H2020 projects). The PhD student and post doctoral fellows were noticeably international representing both number of nationalities and further personal experience in a large number of countries. However, there should be a stronger emphasis on involvement in more H2020 proposals for the remaining period including in leadership roles.

Recommendation 4: The Centre should build a more active and visible international role, participation in EU-funded consortia is especially recommended.

4 Researcher training and engagement in education

The Centre has a goal to train 20 MSc’s, 10 PhD’s and 6 post docs. Thus far one PhD and four MSc students have graduated. We met five PhD students and one postdoc during the site visit. The students and post doc were excellent and dedicated to their studies. There is a retention risk with respect to postdocs as their expertise is in demand for permanent industrial positions elsewhere. The training and mentoring by individual PIs seems consistent with expectations and the personnel employed with FON appear pleased with their environment. The postdocs and students are taking courses in order to improve their skills in areas of immediate relevance to their work. We encourage the Centre and in turn individual students and postdocs to take courses in aspects other than science (for example, leadership etc.). There may be a need for more bioinformatics training for some of the students. Although there was no common curriculum, the students clearly had intense peer to peer collaborations and other shared activities. Their interaction with industry was extremely good, and most of the students had a clear and ambitious view for their careers in the industry.

Recommendation 5: The Centre should put more effort into the personal development of the next generation of scientific leaders as represented by its Early Career Researchers and this should include mentoring programmes tailored to individuals.

5 Plans for final three-year period

Research plans were clearly presented for the final years of the Centre. These included: work focussed on the up-scaling of the novel yeast technology and verification of new methods of improved feed efficiency; continuation of existing work on seaweed based feed and feed components, and the added value of novel feed ingredients on animal health; advanced methods to upgrade nutritional value of grass; and the development of a strategy for research on insects.

The Centre is encouraged to focus in areas of importance to its industrial partners where it is internationally differentiated and to examine its research areas carefully to ensure its research both addresses underlying research questions and is hypothesis driven unless work is purely technological and objective driven. Given the requirement to focus, the review team consider that the level of resource put into the development of the insect strategy should be appropriate to such an exploratory activity.

6 Organisation and Management of the Centre

The centre has a clear vision and identity captured by its aims. It has a committed and carefully organised board that is performing well and is very ably led, organised and managed. The Centre is a flagship activity for the institution. Participation and collaboration between research partners is good. There are some opportunities to improve communication within the Centre and presentation of the Centre externally as discussed in the recommendations.

Recommendation 6: The Centre should think more carefully about how it presents itself with respect to the depth and excellence of its science, its branding and scale including add-on projects and whether they are traceable to the Foods of Norway funding, and innovation and knowledge transfer to industry. This should consider the different audiences it is necessary to reach ranging from peer scientists through industry to the general public.

7 Innovation and value creation

In total the centre has 13 core industrial partners, 4 supporting partners and 8 academic partners.

The core industrial partners are divided into five main groups, each group is represented in the Board. The partners cover several value chains for animal production. The evaluation team was impressed with how the industry articulated its needs through these different value chains and the way that the different work packages fit those needs. It was also clear that several industrial partners have had clear interactions with and knowledge transfer from the researchers in the centre. There are also good plans to increase the knowledge transfer from the different work-packages. However, the evaluation team are concerned with respect to WP 6. We note that this research recently received approximately 10 MNOK for an associated project. This is very commendable. We emphasize that the board should support the WP6 leader in working to cross fertilize the associated project with partner and Centre activities. This work must clearly have a sustained resource from the centre to build real and relevant industrial case studies in LCA and techno-economic business cases, etc.

The centre has delivered several packages of knowledge to industry for innovation and there is clear evidence of more to come. This is highly commendable. However, the evaluation team think that this could be presented in a much better way to Centre benefit and that the overall goals for the final period must be clarified. With respect to innovation, it was not clear in a number of cases which partner or partners were the beneficiaries or potential beneficiaries of the knowledge transfer or whether the knowledge transfer for exploitation require to be made to those outside the immediate partners. We also consider that the centre should think about presenting its impact on industry in a more structured way, in order to emphasise and communicate the total impact of the centre. This will help the centre to attract more partners and to find further opportunities for new associated projects.

The interaction between partners and PhD and Masters students is good, but there are some missed opportunities. We consider that the board should identify at least one Masters thesis project for each partner as a matter of urgency to secure (as a minimum) impact from the centre on all businesses engaged with it. We also think there are opportunities to increase the interaction between the PhD students and industry, by for example students spending a mutually useful length of time in an industry partner or by site visits to all partners from the whole of the PhD group. We encourage the centre to allocate resources to the PhD group to permit this type of activity.

We commend the Centre on its efforts in co-publication with partners and hope that this can be even more apparent in the final period. Co-publication shows both the strengths of the Centre and the impact from the Centre's research.

The self-evaluation document and industry questionnaires give the impression that industry varies in its opinion on to what extent it has secured impact from the Centre for example in knowledge transfer. A measure that is considered critical by the panel is the response to the "has the Centre influenced the R&D and innovation strategy of your company" query. The average score here is 3 out of a maximum 6. The review team emphasize that this must be improved as a matter of urgency. The main responsibility to secure improvement lies with the board as this is where the representative perspective of industry can directly input to the Centre management.

The review documentation and discussion during the meeting showed that the Centre is aware of IPR and the issues related to it. However, the evaluation team consider that the approach of the Centre to IPR could be improved and further formalized. While we saw clear capture of disclosures and of good processes for review of publications for IP, we did not see clear evidence of an overall IP strategy that was understood by all in the Centre. This should be addressed by the board and management team in order to better secure arising IP from the centre. A key part of this will be to ensure that more of the researchers and PhD students have understanding and dialogue with respect to Intellectual Property Assets in the Centre and the likely importance of IP in their future scientific careers. This could be achieved via workshops with invited experts able to use exemplars relevant to the work of the Centre.

Recommendation 7: The Centre should continue to work hard to better engage industrial partners that are less close to it. There is an opportunity to further enhance the relationship with industrial partners by delivering more industry centric Master's student projects.

8 Funding and financial aspects

The Centre has an excellent balance of cash and in-kind contributions from industry. This gives the centre opportunities to act dynamically. We were pleased to see that the centre had not yet allocated all its funding to projects. This gives the centre important flexibility to start new projects either initiated by the management team or the board.

The value of associated projects secured so far is approximately 50 MNOK, which is praiseworthy. When presenting its finances, the centre should present associated project that directly originate from results from the Centre separately from other associated projects to better show the impact from the centre. This is even more important for the final period of the Centre and beyond.

9 Gender aspects

The evaluation panel commend the Centre for its demonstrable equality of opportunity at all levels.

10 Future activities

The Centre has begun to think about the options to build upon the know-how, protectable intellectual property, and infrastructure platforms created with the current SFI funding. These range from new SFI bids, bids for EU and Nordic Centre of Excellence funding, and significantly other sources including from investors.

11 Conclusion and recommendations to the centre

During the evaluation meetings it became clear that Foods of Norway is a high performing Centre serving an important sector of Norwegian industry. The Centre is well led and organised and has an excellent board and committed and energetic researchers. There are, however, a number of opportunities for improvement reflected in the recommendations below:

Recommendation 1: The Centre should set itself publication targets reflecting its aspirations and potential to be a world leading centre in its field.

Recommendation 2: Discussions identified that communications could be improved within the Centre to both enhance the understanding of individual researchers of the overall aim and objectives of the centre and to improve coherence within each work package and across the work packages. This could be achieved either “top-down” or by appropriately resourced “bottom-up” activity led by the Research Assistants and PhD students.

Recommendation 3: As the Centre Task Force considers the routes for the commercialisation and scale-up of its yeast technology it should consider what additional capabilities may be required in biochemical engineering and for large scale animal work. The Centre should also consider the structure of Work package 6 so that it both retains and deepens its core capability in LCA and expands upon it to embrace the broader business and economic issues associated with the commercialisation of the Centre technologies.

Recommendation 4: The Centre should build a more active and visible international role, participation in EU-funded consortia is especially recommended.

Recommendation 5: The Centre should put more effort into the personal development of the next generation of scientific leaders as represented by its Early Career Researchers and this should include mentoring programmes tailored to individuals.

Recommendation 6: The Centre should think more carefully about how it presents itself with respect to the depth and excellence of its science, its branding and scale including add-on projects and whether they are traceable to the Foods of Norway funding, and innovation and knowledge transfer to industry. This should consider the different audiences it is necessary to reach ranging from peer scientists through industry to the general public.

Recommendation 7: The Centre should continue to work hard to better engage industrial partners that are less close to it. There is an opportunity to further enhance the relationship with industrial partners by delivering more industry centric Master’s student projects.

David Williams (Chair)

Kristiina Kruus

Mattias Lundberg

John O'Doherty

10 April 2019

CtrlAQUA – Centre for Closed-containment Aquaculture

1 Introduction

The evaluation

On 8 March 2019 the evaluation team met with the Chair and members of the Board, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, Nofima. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

The Centre

CtrlAQUA is funded to develop technological and biological innovations in order to make closed-containment aquaculture systems (CCS) a reliable and economically viable technology that can be used in strategic parts of the Atlantic salmon production cycle. CtrlAQUA will contribute significantly to solving the challenges that will severely limit the envisioned growth in Norwegian salmon aquaculture. The importance of the Centre is underlined by the participation of small and large enterprises the participation of which highlights the critical role of the Centre as driver for innovation. However, the industry stated that the implementation of innovations from the centre is exclusively theirs. This seems to be acceptable as long as shared resources (coastal zone) and societal interest (ecosystem protection, animal welfare, ...) are not violated. The Centre, consequently, may also take the role of push fundamental innovations towards the industry in order to keep aquaculture viable in a drastically changing environment.

2 Research activities

Research competences and research program, including long-term industrial research

Future aquaculture requires novel concepts that apply best practice in order to comply with animal welfare. Further, environmental issues need to be managed in order to sustain aquaculture production in coastal areas where aquaculture might interfere with natural productivity. Thus, contained (CCS) and semi-contained (S-CCS) aquaculture systems must provide at least part of the future for sustainable aquaculture. The two aims of this Centre, bringing S-CCS, which are floating installations in the sea, into operation and optimising RAS technology on land, are therefore extremely important for the further development of the Norwegian Aquaculture industry.

The consortium is very strong, providing both an appropriate multidisciplinary expertise profile and critical mass. It includes an impressive range and balance of industry and R&D partners and good systems are in place for research planning and development. The research facilities provided by the consortium are impressive and appropriate. The interdisciplinary, professional cooperation and good personal interaction are recognisable strengths of the Centre.

In general, the Centre has been active and successful. However, the evaluation committee has some comments to make and concerns to raise about specific projects. These are listed below and were discussed extensively during the site visit. The evaluation team was satisfied that the Centre understands our concerns and will take them into account, which will make their program better still.

On the basis of these concerns, recommendations are made below, and a consolidated version is given in section 5.

In the preceding years research has focussed on general aspects of smolt production with an emphasis on robustness especially during the transfer to seawater production systems (BARRIER). The fundamental research carried out indicates a possible osmoregulatory contribution of the skin. This could be of importance as the skin lesions occur especially during the transfer to seawater production. If the hypothesis can be verified, skin lesions possibly affect fish health also through an interrupted osmotic regulation.

Effects of the rearing system, stocking density and acute stress on molecular responses in skin were assessed by transcriptome analysis. Gene expression as response to stress occurred 24 h after severe stress challenge.

Gene expression in the skin showed different response in post-smolts reared in flow-through aquaculture systems (FTS) and recirculating aquaculture systems (RAS). The response was more pronounced in FTS compared to RAS. Stocking density was found to be the weaker effect. The effect of full salinity in FTS compared to 12 ppt RAS could not clearly be separated from the effects the systems may have had.

The results show that stress conditions in aquaculture are affecting a large organ of the fish that is at the same time the interface between the internal and external environment. The fish skin plays an important role in the protection against the intrusion of pathogens. The evaluation team concluded that it would be beneficial to S-CCS and RAS (CCS) to focus on technology solutions in order to minimise stress level. Mortality in aquaculture is a waste of resources.

The mechanisms inducing stress in aquaculture systems are well investigated and described. Stress is induced in aquaculture by inappropriate environmental conditions that may entail unwanted aggressive behaviour. It is, therefore, desirable to assess stress induction from the point of view of hydrodynamics (project group HYDRO) as this is determining environmental conditions in RSA (CCS) and S-CCS environments.

The observed delayed recovery of immune function in the skin after transfer into seawater emphasises the fact that S-CCS and CCS rearing facilities, which reduce contact with fish pathogens, are a promising opportunity to support animal welfare during the first months in the sea. In general, S-CCS and CCS are supportive to overall fish performance, health status, and welfare (BENCHMARK) compared to open installations such as net cages. This especially refers to water temperature as a variable highly affected by global change.

A broad piece of the Centre's research was in threshold concentrations for carbon dioxide in S-CCS and CCS (RAS). Even though this is a well-investigated field and recommendations on optimal concentrations are available, the problem is still present in the employed installations and so the Centre is working on resolving it as a matter of urgency. The evaluation suggests that in addressing this issue, the Centre emphasise engineering solutions than for science. Results from international project partners are available and should be analysed, together with the HYDRO research group. Water renewal in S-CCS and CCS seems to be crucial for the animal welfare in respect to variables such as temperature, dissolved oxygen and nutrient concentrations.

Closed-containment aquaculture systems in the sea allow maintenance of appropriate environmental conditions inside S-CCS and CCS. This refers especially to water temperature which is the most limiting factor in contemporary coastal aquaculture. Another benefit may be the avoidance of

pathogens. However, the evaluation team feels that the possible environmental impact of S-CCS must be thoroughly assessed. Seawater from greater depth is brought up to the surface (INTAKE) and flows down again after discharge from the containment. If multiple S-CCS are operating in the same area, a significant volume seawater from greater depth is moved upwards and downwards. An inclusion of the HYDRO research group should be considered in this work.

Another aim of using seawater intake from a greater depth is that it is possible to avoid transfer of pathogens. This would probably require a pre-treatment (filtering) of the intake water. The upward pumping of water seems to consume a minor amount of energy compared to the energy needed to compensate the pressure loss in filters. If very small pathogens (particles) are to be removed through small pore size, the energy consumption will be tremendous. Furthermore, the backwashing of filters will become extremely complex. Thus, an early involvement of engineers is necessary and that must be based on performance specifications.

A similar topic is the disinfection of seawater used in S-CCS and CCS. The removal of pathogens from the process water seems to be complicated and energy consuming. The results so far show that a higher particle load interferes with the disinfection process. A maximum of 3-log removal in bacteria number was achievable. It seems that a strategy of pre-treating the intake water and maintaining favourable conditions in the holding environment would be a way to manage animal welfare in S-CCS and CCS and should be approached in future research. From this point of view the research team MICROPARASITES can make a valuable contribution.

The particle load in S-CCS and CCS seems to be a major constraint of close containment aquaculture (PARTICLE), to be solved by engineers. Appropriate tools seem to be available from industries involved in the CtrlAQUA project. The evaluation team wondered whether technical changes to the piping would resolve most of the problems. This includes the formation of hydrogen sulphide gas which is highly toxic at high concentrations, but also has effects on metabolic pathways during long-term sub-acute exposure. The detection of hydrogen sulphide in the process water is certainly helpful if sub-acute concentrations are detected. At the end, it will certainly be necessary to rethink the hydrodynamics in pipes, components, and tanks. This may also involve the HYDRO group. It also seems to be necessary to focus on the maintenance of pipes, components, and tanks as settled particles may support the microbial formation of hydrogen sulphide gas. Thus, a guide for best practice should be made available as a deliverable from CtrlAQUA.

A very good and promising expansion of the research was stimulated by the international advisory board. It was recommended that the plastic pollution should be addressed from the point of view of aquaculture, where it is a potential polluter. In taking that recommendation on board, the Centre is likely ahead of science and will be capable of delivering first insights into this striking topic of global significance and importance.

Scientific publications (including co-publications with user partners) and papers at recognised international conferences

In relation to the size of the Centre and its duration to date, the record of publication in international peer reviewed journals is modest, although these publications are in appropriate international aquaculture and fish biology journals. As one would expect, a momentum is building up, with many publications in 2018, but the Centre is well short of its own target of 100 papers in peer-reviewed journals. This is balanced by a good record of publications directed at dissemination to more general audiences including the aquaculture industry, which is entirely appropriate for the Centre's aims.

The Centre has a very good record of participation in conference, workshops and meetings at a local, national and international (1/3) level, also with an increasing number up to 2018. In terms of subject matter this participation is reasonably well balanced across projects.

Research profile and international visibility

The Centre has an excellent research profile, with strong visibility within the Norwegian aquaculture industry and among aquaculture researchers from other countries, especially those working on RAS technology. The fact that so many international students are attracted to the training offered by the Centre speaks to this high profile.

One special feature of the Centre is its remarkable openness with regard to sharing of ideas and knowledge. This was singled out for strong praise by one international partner: "We continue to be amazed at how open, cooperative, and engaging all of the Centre's scientists and industry partners have been throughout the project. This is unique in our experience and has been a pleasure for all of us...". This genuine and highly commendable openness contributes to the profile of the Centre and elevates the socio-economic impact of its research.

The Centre is likely to gain increasing international attention as it is focussing on the aquaculture of Atlantic salmon, which is expected to grow in all regions of the world. The development of technological leadership can be expected to be an outcome of the intensive interdisciplinary research carried out in the Centre. The leadership is supported through well-developed international cooperation, as well as through links with globally operating enterprises.

3 Internationalisation

International research cooperation, e.g. EU's framework program

The level of international research cooperation is excellent. The Centre is well embedded and well respected in the international research community involved with RAS, through a variety of funding programs, including the EU's Framework program.

Collaboration with international research groups

The Centre has good research collaborations with several international research groups, at the level of industrial and R&D partners, individual researchers and postgraduate students.

A very attractive part of the internationalisation is the collaboration with the Freshwater Institute, Shepherdstown, West Virginia, USA. The Freshwater Institute is intensively investigating the freshwater aquaculture of Atlantic salmon. The research into the marine aquaculture carried out by the CtrIAQUA centre is, therefore, complementary and of mutual benefit to both research teams. The knowledge exchange is well established and supported through the participation of scientists and students in CtrIAQUA.

Foreign senior researchers, postdocs and PhD students in the Centre

Personnel at the Centre include many people from outside Norway. This is the case among the research partners and through Associated Projects. It is strikingly the case among postdoctoral researchers and graduate students.

The high number of incoming students helps to disseminate the technological advances achieved in the Centre. This happens on an international level, so that a global spread of Norwegian technology can be expected. Strong ties to customers can be expected from the intense academic education and training. Thus, the Centre has impact far beyond science and engineering. This is certainly

appreciated by the participating enterprises and is, of course, of discernible benefit for research institutions and universities in Norway.

4 Researcher training and engagement in education

Researcher training

The Centre does not have a formal scheme for researcher training and exchange of expertise between industrial and R&D partners. However, it is clear that overall the level of discussion and exchange of information through the Centre's various activities (from attendance at Annual Meetings and thematic and project planning meetings to one-to-one meetings between Coordinator and partners) serves well to meet these training requirements. A need has been identified for a specific short training course on RAS, and the Centre is to be commended for taking this on board.

The partner NTNU hosts a regular RAS course. The number of participants has significantly increased during the past years. It is worth considering whether the experimental facilities of the Centre could provide further opportunities for capacity building, possibly in cooperation with NTNU. The Centre could become an enormous driver for the novel S-CCS and CCS technologies, especially through education and training.

Engagement in education on Masters and PhD levels

In spite of having taken a policy decision not to use internal funding for student stipends, but to cover the cost of all student research, the Centre is well on course to meet its target of training 15 PhD students. The evaluation team had some concern that, having their stipends paid outside the Centre (by University of Bergen and NTNU), students may identify with the host university rather than with the Centre.

On the other hand, the research infrastructure of the Centre, as well as the opportunities given through the collaboration with numerous academic groups, is of great benefit for the research carried out by the PhD students. The students clearly communicated their appreciation of these opportunities.

Studentships associated with the Centre have proved very attractive internationally. In discussion, the young researchers (PhD students and one post-doctoral researcher) showed themselves to be very well satisfied with their training/research environment and clearly value contact with industrial partners. Depending on the project, this takes place naturally during research activities and also during Annual Meetings. The evaluation team felt that students would benefit from a more formal interface with industrial partners.

An emerging difficulty may become the recruitment of personnel for the industrial partners in the Centre, given the low proportion of Norwegian PhD students. One suggested reason here is that most of the Masters students are hired by companies before they have finished their studies and moved on to doctoral training. At least for appropriate parts of their research effort, the industrial partners in the Centre have chosen to participate in the Centre's research rather than to carry out experiments in their own laboratories. In view of the potential benefits of the Centre's research for the Norwegian aquaculture industry, it would be desirable to make the Centre a focus of recruitment for highly educated scientists for the industry. This would not only foster science but also support the build up of science teams at the Centre. An important step has already been taken with having at least one industrial PhD in an associated project. Such investment into research and development will certainly pay back on a short time scale, as S-CCS and CCS are complex technologies requiring highly trained personnel, especially if they become integrated in recycling processes.

Recommendation 1: That the Centre make the student interface with industry more formal; including providing appropriate background training in issues such as intellectual property, scaling up and safety and increasing the number of industrial PhD students.

The participation of students and doctoral students in international conferences is supported and will promote an ongoing collaboration and knowledge transfer between younger academics.

Responsibility for converting conventional aquaculture into a sustainable technology supplying safe and affordable food to a growing world population will fall on the upcoming generations of researchers and engineers. It can be expected that this new generation of researchers will focus on the necessity of the adaptation of technologies, rather than following static concepts and goals of the global economy that will largely be inappropriate in future.

5 Plans for final three-year period

Assessment of the plans for research activities for the centres' final three-year period

CtrlAQUA is heading in the right direction, but research to date has tended to focus on monitoring and analysis of biotic and abiotic factors rather than overcoming technological hurdles. In the next phase, it would be wise to draw more on the field of process engineering, using the results from fundamental science to develop efficient and safe processes. To promote technology transfer, the Centre must seek user partners that are interested in upgrading CCS/RAS and S-CCS installations.

Plans for the final 3-year period include:

1. a continuation of current research themes, the broad aims of which are considered still to be valid; and
2. three specific projects arising from pressing problems identified by industrial partners, relating to early sexual maturation, formation of H₂S, and increasing incidence of nephrocalcinosis.

Concerning the hydrogen sulphide problem, the evaluation team was strongly of the opinion that the biology underlying the relevant problematic issues is sufficiently understood, partly through the Centre's own work, for production and welfare solutions to benefit from a change of emphasis in the Centre's approach to this to be increasingly towards engineering solutions that keep H₂S levels below the known maximum for health as opposed to biological studies of how fish respond to increased concentration.

Concerning nephrocalcinosis, the Centre came up with results indicating that an increase in dissolved carbon dioxide concentration up to 40 mg resulted in moderate compensatory effects on physiology and reduced growth but did not result in nephrocalcinosis. It is of fundamental interest to follow the appearance of clinical symptoms at low carbon dioxide concentrations. This, however, presupposes that the carbon dioxide concentration in S-CCS and CCS is lastingly lowered through additional desorption processes (see below).

The evaluation team was surprised that carbon dioxide concentrations are still at very high levels in S-CCS and CCS/RAS. The scientific literature, as well as successful operators, would recommend concentrations below 5 mg carbon dioxide. The desorption technology in S-CCS and CCS needs to be upgraded – the Centre will tackle this in 2019. The cooperating Freshwater Institute has developed suitable components, detailed descriptions of which have been published. The HYDRO team should support this action through simulation of tank water exchange rates.

In general, fish are complex organisms, responding to a large number of environmental factors that interfere with each other. Engineering solutions that let water conditions remain at a quality known

from the natural distributional range of the fish species appear to be a valid and straightforward concept. The evaluation team recommends a shift in emphasis towards such solutions for the final 3 years of the project.

The evaluation team accepts that this recommendation requires an upgrade of the existing technology and so may not be in line with the expectations of industry. In the long run, however, this will ensure sustainable aquaculture production and, eventually, acceptance of products by customers.

Recommendation 2: That the Centre change its emphasis from further documenting the problems in S-CCS and CCS to working with industry partners (& their engineering divisions) to finding solutions through systems and engineering, not through putting additional demands on the fish.

In addition, the evaluation team was concerned that Centre's research aims do not include consideration of the environmental impact of area and water usage involved in deployment of RAS. This is especially the case for S-CCS, which involves extraction and recirculation of very large amounts of water (more than 200 million $\text{m}^3 \cdot \text{a}^{-1}$ for one medium-sized unit according to a quick estimation). There is a risk that, however well designed from a technical and a biological point of view, such systems may eventually prove inviable for environmental reasons. The evaluation team recommends that in the final 3 years, and possibly in preparation for future research, the Centre works to identify programs in other centres to address environmental problems arising from using CCS and S-CCS and/or to establish such a program at the Centre.

Recommendation 3: That the Centre ensure that appropriate research programs exist to address environmental problems arising from using RAS. This might be through a new program in the Centre or done in liaison with another centre.

6 Organisation and Management of the Centre

The Centre is well governed and managed. Frode Mathisen, a knowledgeable and involved industry representative, chairs the board. The Director, Åsa Maria Espmark, is dedicated and highly capable, providing excellent leadership in the face of challenges associated with a large number of partners scattered over diverse locations. The host institution, Nofima, supports the Centre appropriately, providing research infrastructure, financial, human resource, and communications services as part of its support.

To maximise the involvement of its partners the Centre runs an interlocking set of structured meetings – annual meetings; thematic meetings; one-on-one meetings with partners (a popular innovation introduced in 2018); and project meetings, all underpinned with extensive document sharing through Sharepoint (Intranet).

The Centre is becoming increasingly visible internationally. Two representatives of international partners spoke highly of the value of the Centre as seen from within their national systems. The number of applications the Centre receives when recruiting doctoral students indicates that it is a popular training destination for foreign PhD students.

The Centre has established a good Scientific Advisory Board (SAB) that attends annual meetings and provides advice there through a presentation and informal feedback. This advice could usefully be formalised further through an annual report, which could be shared with all partners and used as a fundamental document in the annual planning process.

Recommendation 4: That the Centre revise the way it works with its Scientific Advisory Board, requesting the SAB to formalise its advice through an annual report which can be shared across all partners and bodies in the Centre and used as a useful input to the annual planning process.

7 Innovation and value creation

The Centre has 14 user partners, comprising farmers, technology suppliers and biotechnology companies. The involvement of partners in realising the Centre's mission is highly commendable. It was very clear that the partners are truly involved in the way the Centre has evolved. The industry partners give great input in the form of articulated needs to the Centre to identify new research projects. They are also able to take and transform the knowledge output into industry business.

The list of potential knowledge transfer results from the Centre, which are very good, are labelled "Innovations" (see original funding application). The evaluation team thinks this is misleading term for what the Centre actually delivers to the industry partners. We think the Centre will achieve better future visibility (and get a better reputation) if it stated that the Centre produces scientific knowledge and ensures the transfer of this knowledge to its user partners for producing innovations in their in-house operations. The Centre should keep track in a better way of its knowledge transfer results, as well as quantitative and qualitative innovations arising from them in the industry partners' organisations, to illustrate its impact on industry. This will give a higher profile to the industrial and scientific impact originating from the Centre.

Recommendation 5: That the Centre keep track in a better way of its knowledge transfer results, as well as the firm-based innovations arising from them in order to illustrate its impact on industry.

From the interview and from the reading material it was evident that the Centre has several associated and spin-out projects. This is very good. The Centre should clarify which projects directly originate from results produced by the Centre and which are more loosely connected with it. This will also help to highlight the overall impact of the Centre and can be incorporated into its communications strategy.

According to the self-evaluation report, most partners are very satisfied. All partners have clear goals for what they want to achieve through participation in the Centre. However, some partners seem disappointed with the outcomes from the Centre so far. It will be very important for Centre management to set expectations with these partners about likely industrial and scientific impact for the final three years.

As noted above, the interaction between industry and PhDs has not been fully utilized. The evaluation team think this must be formalised in a better way in near future. (See Recommendation 3).

The number of MSc students connected to industry partners is very good, and we encourage the Centre to make more use of Masters students in the future.

8 Funding and financial aspects

The Centre has a good balance of cash and in-kind from industry. The research partners contribute with substantial in-kind resources, including faculty money for PhDs in the Centre.

The evaluation team also noted that there is a good balance between common projects and user-specific projects.

9 Gender aspects

The Centre is very successful in working with equal opportunity. The gender balance at all levels of the Centre is noteworthy for being remarkably well-developed for this field of science, research and development.

10 Future activities

As yet, the Centre has not formulated plans for the period after the end of the RCN financing. However, there was a strong feeling from several partners at interview that having built up such a good consortium of research providers and end users (farmers, technology suppliers and biotechnology companies) and, given the urgency of the research agenda facing them, it would be a mistake not to continue in some form. The evaluation team agrees and suggests that planning for this period needs to commence as soon as possible.

Recommendation 6: That the Centre's Board and management commence formal planning for the organisation that will succeed CtrlAQUA, including planning for the remit, composition and funding of this organisation.

11 Conclusion and recommendations to the Centre

The evaluation team appreciates that the Centre could play a determining and regulating role in the development of the aquaculture in Norway and worldwide. This is, on one hand, because of the importance of the aquaculture of Atlantic salmon that is spreading worldwide, and, on the other hand, because of the importance for the economy in Norway. The Centre has already developed a lively environment with multiple partnering activities and, as such, is probably quite unique in this industry worldwide.

The Centre can be seen as a cornerstone for the development of a part of the food industry that will certainly gain importance as the natural aquatic resources are to a large extent depleted. Inappropriate development of aquaculture will repeat similar mistakes that unfortunately seem to have been caused by an overemphasis on economic interests at the expense of sustainability. Accordingly, more research is needed across the industry generally on the protection of environment and the shared aquatic food resources.

The great strength of this Centre is that it has brought together an excellent complement of partners to tackle the problems of contained and semi-contained systems, thereby providing valuable support for the national sustainable aquaculture industry with a special ability to mobilise quickly to troubleshoot major problems that have come up as the industry has expanded.

However, there are several aspects of the Centre that could improve and, accordingly, we make the following recommendations.

Recommendation 1: That the Centre make the student interface with industry more formal; including providing appropriate background training in issues such as intellectual property, scaling up and safety and increasing the number of industrial PhD students.

Recommendation 2: That the Centre change its emphasis from further documenting the problems in S-CCS and CCS to working with industry partners (& their engineering divisions) to finding solutions through systems and engineering, not through the fish.

Recommendation 3: That the Centre ensure that appropriate research programs exist to address environmental problems arising from using RAS. This might be through a new program in the Centre or done in liaison with another centre.

Recommendation 4: That the Centre revise the way it works with its Scientific Advisory Board, requesting the SAB to formalise its advice through an annual report which can be shared across all partners and bodies in the Centre and used as a useful input to the annual planning process.

Recommendation 5: That the Centre keep track in a better way of its knowledge transfer results, as well as the firm-based innovations arising from them in order to illustrate its impact on industry.

Recommendation 6: That the Centre's Board and management commence formal planning for the organisation that will succeed CtrlAQUA, including planning for the remit, composition and funding of this organisation.

Mary O'Kane (Chair)

Felicity Huntingford

Mattias Lundberg

Uwe Waller

21 March 2019

Klima2050

Risk reduction through climate adaptation of buildings and infrastructure

1 Introduction

On 2 April 2019 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives, postdocs, PhD students, and representatives of the host institution, SINTEF. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

The Centre's focuses on how to reduce risks for buildings and infrastructure as the climate is becoming more extreme towards 2050. It addresses impacts caused by increased precipitation including more moisture, more flooding and more landslides. It does so both from natural technical science and social science perspectives, and in collaboration with user partners. This broad focus and width in scientific disciplines is extraordinary, but truly reflects the diverse and multifaceted challenges of climate change and recognized as being an adequate approach. This is especially so, considering the short history of research and innovation within climate change adaptation, and the need for massive societal changes in short timeframes.

The research program of the Centre is divided into four work packages, with WP1 on moisture resilience of buildings, WP2 on storm water management, WP3 on landslide management, and WP4 on decision-making processes. All WPs contribute with research within their respective focus areas, as well as with innovation by collaboration with user partners. WP4 plays a cross-cutting role, engaging with the other three WPs.

A total of 31 senior staff members are engaged in the Centre, spending from 10 – 50 % of their working time in the Centre, and with affiliations distributed across five different institutions: SINTEF, NTNU, BI, NGI and MET. All staff members have relevant competences, although it should be noted that seven out of the 31 listed senior staff members hold MSc degrees, but not PhD or Dr.ing. degrees. This may be considered a weakness in terms of their ability to ensure publication of research findings in peer reviewed international journals, although one (Cecilie Flyen) has authored and co-authored three of the 20 papers listed as the most important, and it can be noted that 11 of the senior staff members with a PhD or Dr.ing. degree have made no contributions to the list. From the CVs of the eight members of staff who form the Centre's core management team (Berit Time, Tore Kvande, Tone M. Muthanna, Edvard Sivertsen, Anders Solheim, Jose Cepeda, Åshild L. Hauge and Lena Bygballe) their competencies are fully adequate, with fine peer reviewed publication lists for all, and three of the members having experience with PhD supervision. Considering the disciplinary spread between WPs, the number of staff is sufficient, though not excessive, to produce

results within their own WPs and, at the same time, to contribute to the Centre's innovation activities, e.g. through collaboration between WPs in the Centre and with user partners.

Regarding WP1, the two key partners, SINTEF and NTNU, have a long track record of collaboration both with each other and with the building industry, where they have, for many years, provided guidelines and standards to the building sector, with some reaching national statutory level. For WP2 and WP4 the engagement in industrial research seems less well established. WP3 is well-founded in the tradition for geotechnical research based advice.

During the first 3½ years of operation, the Centre has published 28 papers in peer reviewed scientific journals, two of which are in Norwegian. The journals cover a broad field but 'Buildings', 'Journal of Building Physics' and 'Water' are used more frequently than others. These journals are recognized within their fields but are not the highest ranked ones. All papers have at least two authors, and many have three or four. Although the distribution of papers across individual WPs is not stated in the assessment material, based on the titles it appears that most papers lie within WP2 and WP1, while WP3 and WP4 appear to have produced fewer papers. Likewise, the share of papers authored by PhD students is not clear, but papers related to PhD studies seem to make up around 25%. The total number of scientific publications is somewhat less than the annual target of 15, although in 2018 the target was exceeded, which reflects increased outputs from both PhD studies, case studies and pilot projects. There are five publications listed as co-authored with user partners. Of these, one is published in an international, peer reviewed scientific journal.

One PhD thesis has been published and another will be defended in May 2019. The Centre lists 56 contributions to conference proceedings; this is at a reasonable level. It should be noted that the Centre has contributed a substantial number of additional publications, including Klima 2050 reports, technical papers and Klima 2050 notes, as well as many oral presentations at Norwegian conferences, seminars and meetings, and a high number of news announcements and press releases. This reflects the ambition of the Centre to become recognized as a national knowledge base, and to establish a network for future research and innovation activities with users.

From the self-assessments provided by user partners, it is evident that the majority of the partners appreciate the research components of the Centre, with the majority pointing to long term investment in knowledge building. There exist among the private user partners examples of companies that have either reorganised themselves or strongly invested in research activities as consequences of opportunities offered by their collaboration with the Centre.

The research profile reflected in WP1 and WP3 is at a high international level, representing excellence, especially in WP3 which was awarded a 'World Centre of Excellence' prize by the International Consortium for Landslides (ICL) in 2017. WP1 has put forward a great ambition of suggesting a framework for how to make climate-resilient buildings, which may add a new level to the building regulations in Norway. This is a bold step, which may drive research in the field for many years, continuously delivering improved guidelines on many aspects of climate resilience. The use of membranes to allow for construction of compact, still moisture-resilient, wooden roofs also appears to be a strong result, reflecting an already advanced approach to the field. This research was carried out by the first PhD student under the Centre. Regarding WP3, the recently launched web-based decision-support tool, LaRiMiT, for landslide mitigation reflects state-of-the-art knowledge in the field. This is also the case for the suggested early warning system based on pore water pressure conditions which is an innovative approach. Regarding WP2, the significant research on green roofs, including a PhD study focusing on runoff hydrographs from different types of roofs, represents a breakthrough for the research at SINTEF and NTNU on green roofs and forms a solid base for future

research. Although the findings may not represent ground-breaking new research in a field that is already rather well studied, e.g., by Virginia Stoven from Sheffield University in the UK as well as others, it adds a new layer of knowledge regarding a cold Nordic climate and different types of roof. Further, this research has laid the ground for the advanced test site now established in collaboration with Trondheim Municipality. This all reflects some solid and sound, natural and technical research skills. Regarding WP4, the agreement with Finance Norway on sharing of loss data from its organisation's insurance companies is considered a breakthrough that may open up new avenues for research. How this breakthrough was achieved is not fully clear, but it seems that a trustful alliance has been established. The planned WP4 activities on testing uptake of LaRiMiT by targeted end users are promising and an example of cross-WP collaboration emerging directly as a result of the Centre.

Although the international visibility of the Centre may not yet be at a very high level, the number of visiting researchers and PhD students, as well as the involvement of more of the research partners in new international projects, as stated in the next section, are clear signs that the Centre is becoming more visible.

Recommendation 1: That the Centre ensures that WP4 collaborates with the other WPs and user partners to inform planned work on future socio-economic methodologies and analyses of climate change innovations. Deliverables should include co-authored journal papers with industry and researchers from other WPs, and input to associated projects.

3 Internationalisation

The Centre's research partners have been successful in winning five international projects: four with Horizon 2020 funding and one in collaboration with the University of Minnesota, funded by RCN. As a measure of the international activity on research application, the Centre has also been a member of consortia for five other international projects. Recently, five publications in international journals have been published in collaboration with international partners. In 2018 alone, five organisations from other countries (one Chinese, two Italian, one Swedish, and one German) and five researchers (four Italian, and one Swedish) have taken active parts in Centre projects. In addition, three international researchers (from China, Canada, and the USA) have stayed more than two weeks with the Centre, and four researchers from the Centre have visited institutions in other countries (UK, USA, and France) for more than a month. Regarding recruitment, seven out of the Centre's 13 PhD students have a nationality other than Norwegian (Czech, New Zealand, USA, Ethiopia, Spain and Italy) and one postdoc is of Finnish nationality. On the Nordic level, the Centre has collaborations with VTT (Finland) and Chalmers University of Technology (Sweden) and the Centre became known for hosting the Nordic Symposium on Building Physics in 2017, which attracted quite a number of researchers from both within and outside the Nordic countries. This symposium had a session on Climate Adaptation inspired by the Centre, and during the interview, it was mentioned that the Centre has a strategy to consider other international conferences for sessions on this topic. All in all, the amount and quality of international activity is satisfactory but there is scope for more and this could be important for the sustainability of the Centre, especially after the SFI funding period.

Recommendation 2: That the Centre incentivises both outgoing and incoming international exchanges for researchers at all levels.

4 Researcher training and engagement in education

The Centre's approach to researcher training is an example of good practice across the SFI programme. The Centre has a Research Training Committee, led by Prof. Tore Kvande and managed

on a daily basis by a postdoc, Jardar Lohne, as a facilitator. An intricate structure has been devised on how relationships work between PhD students and MSc students, who often complement the research of the PhDs and the wider Centre. It is impressive that the PhD facilitator invests 50% of his time as a postdoc to organize this effort. On a daily basis, the PhD's are gathered in an open space office, which forms one of the hearts of the Centre.

Central parts of the research training activity are two day seminars, which are held every nine months. The gatherings have significant social dimensions, but also learning elements such as oral presentation training (e.g., in Pecha Kucha), publication techniques (e.g., on scientific writing), ethics, and other scientific training elements, such as a lecture on climate change.

In discussion with the PhD students, some appeared to have just a moderate awareness of their position within and significance to the Centre. Their involvement with the user partners is somewhat limited although some are co-supervised by representatives of the partners. There are also some examples of co-publication with the user partners. Involvement of the PhD students in the pilot projects is sometimes good. Altogether, there are traces of good involvement of the PhD students in the overall Centre structure, but the interview left the clear impression that this is an area that could be enhanced. The setting for the PhD students seems to be very safe and pleasant for them, which is good, but the question is whether the PhD students should be challenged more, e.g. by being more strongly encouraged to take short term stays at relevant research institutions abroad and by engaging in longer term collaborations with user partners. The majority of the students were planning careers in the private or public sectors, and few presented ideas for future research or collaboration options.

Engagement in education at Master level is extremely successful. The Centre has engaged a significant number of MSc students (56), and the Centre's research is a very popular theme for the students to work in. The Centre has a good reputation, and little effort is needed to attract future students. There is a good balance in gender representation among the students.

Recommendation 3: That the Centre improves collaboration between the PhD students and user partners and, in so doing, creates mutual benefits.

5 Plans for final three-year period

The Centre presented a convincing plan for the last three years of the project. The plan addresses well issues raised by the International Scientific Advisory Committee. From discussions at the interview, the following improvement opportunities were identified:

- more integration of work between the work packages, strengthening potential synergies;
- a more evident international profile; and
- ensuring that the PhD's are more engaged with the partners and become more internationally exposed.

The Centre has KPIs for 2019 and some have quantifiable targets. The plan comments on the research tasks (within work packages) and presents a very satisfactory plan for where the focal points of the final three years' activities should be. It is very good that the research plan has clear ambitions for future pilot projects associated with each of the four WP's and that budget has been allocated for their execution, even in cases where the projects have not yet been defined. This can already be seen as partial fulfilment of Recommendation 5 (see Section 7).

6 Organisation and Management of the Centre

This is a large, high performing Centre with 15 user and five research partners. The Centre is very well organised with a clear structure that facilitates a large volume of activity across all levels. The director, and chair and deputy chair of the Board provide outstanding leadership and the dynamic between people at the evaluation meeting provided evidence of a high level of trust between participants. Together this provides an extremely good foundation for the final three years and beyond.

There is some cross-work package working, e.g., through pilot projects and between PhD students. The evaluation team is confident that more will come and expect this to improve the international reputation of the Centre (see Section 3). The Centre's research is very well aligned with one of the hosts' prioritised research areas, climate adaptation, and the host is very supportive of both the Centre management team and Board, and the Centre director.

The internal identity of the Centre is coherent across all levels. During the day it became apparent that the full scale of the work and achievements of the Centre is significantly more than that reported and evident from external media such as the web site and annual reports, all of which are, in themselves, excellent. We encourage the Centre to improve the visualisation of the totality of their research and innovation achievements in order that it can feed into society, international academic arenas, and future research with existing and new partners, e.g., through associated projects.

From the reports and during the interview, there are scientific and innovation goals within the Centre. However, these were fragmented and not used to drive activities within the Centre. In particular, the scientific goals are not quantified and the KPIs for 2019 from the Board are quantified but do not cover scientific outputs. For example, the Centre's KPIs should include aspects shown on the final slide in the morning presentation such as the number of innovation and pilot projects, number of publications, research infrastructure and capacity, dissemination activities, and number of MSc projects and associated projects. We suggest that the Centre defines a coherent set of performance indicators, covering both scientific and innovation outputs, and quantifies them in a way that allows researchers in the Centre to calibrate their own performance against Centre norms.

It is good that the Centre has a clearly defined communication strategy, but this needs to be reviewed in the light of the scale of outputs to be reported and to ensure that the Director has time to prioritise and focus on the development of future scientific opportunities. For example, even though it is impressive and important in the start-up phase, the evaluation team was surprised to learn that the Director has delivered over 33 of the 175 presentations, lectures, courses and seminars over the first period and takes responsibility for the content of the web site and regular newsletters.

Recommendation 4: That the Centre is more ambitious, setting clear targets for science and innovation, in communicating its full scientific capability and innovations to wider audiences including the international research community. This will be critical to delivering sufficient associated projects to sustain the critical mass of the Centre beyond its funding period.

7 Innovation and value creation

The Centre is commended on its approach to the selection of 15 public and private sector partners. This was done strategically and includes representatives of the majority of stakeholders in the construction value chain.

As discussed earlier (see Section 3), mobility of personnel has been identified as an issue to be addressed in the final period. Co-publication of results between user partners and researchers is good, but knowledge transfer in the final period could be improved as the pilot projects deliver further results. The representatives of Trondheim Kommune and Skjæveland Gruppen provided excellent examples of how the research is being exploited by user partners; this could be used as best practice in the final period and beyond. However, structures to commercialise results that fall outside user partners' core areas need further development.

Since its proposal, the Centre has changed the way in which knowledge transfer projects are generated. The use of pilot projects, with clear criteria for what constitutes such a project, is a very effective mechanism and an example of good practice that could be adopted more widely. However, a constant focus on generation of new ideas, and involvement of all partners, should be cared for.

Recommendation 5: That the Centre systematises its innovation process, including linkages to research and prioritisation of cross-WP collaborations, for the final three years.

8 Funding and financial aspects

There is a good balance of cash and in-kind but we suggest that the Centre, for itself, includes in-kind contributions from the public partners to show the true scale of its finances. The Centre currently has five associated projects: four EU-funded and one a collaboration with University of Minnesota. For the final period, it is important that the Centre identifies more potential associated projects and new partners with a view to maintaining its long term sustainability, especially beyond the end of the funding period.

9 Gender aspects

We commend the Centre on its gender balance on all levels.

10 Future activities

At its last meeting, the Board began a strategic discussion on the long-term future of the Centre. We encourage the Board and management team to identify a range of ways to maintain the Centre's activities for end user innovation and in the international academic community.

11 Conclusion and recommendations to the Centre

The Centre leadership is excellent and the Centre is conducting internationally competitive research in response to user needs and has unique opportunities to be world leading by improving the scientific collaboration across research in the work packages. This mid-term evaluation has however highlighted areas which could be improved further and accordingly our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre ensures that WP4 collaborates with the other WPs and user partners to inform planned work on future socio-economic methodologies and analyses of climate change innovations. Deliverables should include co-authored journal papers with industry and researchers from other WPs, and input to associated projects.

Recommendation 2: That the Centre incentivises both outgoing and incoming international exchanges for researchers at all levels.

Recommendation 3: That the Centre improves collaboration between the PhD students and user partners and, in so doing, creates mutual benefits.

Recommendation 4: That the Centre is more ambitious, setting clear targets for science and innovation, in communicating its full scientific capability and innovations to wider audiences including the international research community. This will be critical to delivering sufficient associated projects to sustain the critical mass of the Centre beyond its funding period.

Recommendation 5: That the Centre systematizes its innovation process, including linkages to research and prioritisation of cross-WP collaborations, for the final three years.

Alison McKay (Chair)

Marina Bergen Jensen

Mattias Lundberg

Carsten Rode

9 April 2019

CASA – Centre for Advanced Structural Analysis

1 Introduction

On 5 March 2019 the evaluation team met with the Chair and members of the Board, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, NTNU. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

The Centre has performed excellent research and has met its overall objective “to provide a technology research platform based on multi-scale testing, modelling and simulation for the development of smart, cost effective, safe and environmentally friendly structures and products”.

However, the Centre would benefit in future communications from a more pithy statement of what differentiates this centre from similar centres around the world. What makes this Centre’s research truly unique and highly impactful and what research challenges is it particularly suited to address?

The Centre's research is well organised with basic research programmes which meet the need for more extensive use of advanced numerical simulations. The research will improve the 14 industrial partners' competitiveness. The main industry goals of the Centre are to develop methods and tools for implementation by industry partners and to ensure the transfer of technology across business sectors. The main academic goals are to graduate PhD candidates, to attract scientists from abroad, and to publish papers in top international peer-reviewed journals.

The Centre has an impressive working capacity covering many fields of mechanics involved in safety and security, with in 2018 a total of 14 senior academic staff, 5 administrative employees, 4 post docs, 11 scientists, 21 PhD students and 21 Masters students.

The Centre has a distinct research profile and its activity is geared to produce research outputs both short term and long term. The level of scientific quality is very high and recognised worldwide through the large number of journal papers with very good citation indices, conference contributions, and keynote lectures ranging from fundamental to applied topics. The publications are often co-authored with user partners or with international academic partners. The core group plays a leading role in editorial work in both Impact Engineering and Solid Mechanics.

3 Internationalisation

The Centre researchers have high international reputations and visibility. The Centre has research cooperation with several international research groups on targeted questions of critical importance to industry. This cooperation is mainly in the form of joint journal publications and conference contributions.

The Centre is not aiming to be a coordinator of EU framework projects, but it has taken part in two EU framework applications that were not funded and is a partner in two existing EU projects as well as a Norwegian-Japanese collaboration project.

The evaluation team suggests that, given that that it is performing very well, the Centre should be yet more active in applying for and leading applications for competitive European funding.

The Centre has 5 international partners from the automotive industry. It has hosted 9 visiting researchers. Centre staff, PhD candidates and postdocs have visited research organisations and companies abroad.

4 Researcher training and engagement in education

The Centre has a well-running organisation for research training. Each research student has a project in collaboration with at least one Centre partner. The PhD candidates follow a study plan that is worked out in cooperation with the supervisors.

The PhD students are collocated in the Centre's premises and feel well supported by Centre staff and partners. There is an open atmosphere in the Centre and the supervisors are available for guiding the research students most of the time. The PhD candidates have had several opportunities for co-publication with their supervisors and each other. Several of the PhD students are close to their PhD examination. Centre staff are engaged in teaching at Masters and PhD levels as well as being supervisors and examiners of Masters theses.

5 Plans for final three-year period

The Centre used its seminar in September 2018 to finalise its approach to its final three years. While it was determined that no modifications would be made to current research methodology and programs, the Centre took on board end-user feedback to increase the focus on industry partners' medium to long-term strategic research needs. This feedback particularly addressed the need to explore and solve problems that limit industry's potential for development and innovation (so-called roadblock problems). This is an appropriate way to proceed combining the current research trajectory, which works well, with an increased emphasis on emerging hard research problems.

6 Organisation and Management of the Centre

The Centre is well organised and governed with appropriate support from the host institution, NTNU. Under the guidance of the Board (which was well represented at interview by several articulate and committed members), the Centre's spirited Director leads a well-functioning organisation which is characterised by clear planning, effective day-to-day administration, excellent research infrastructure and technical support, and very good personnel support (which has led to a strong sense of community in the Centre).

The Centre has a clear identity and is well recognised nationally and internationally. While this is due in large part to the eminence of the research and researchers in the Centre, it is supported by a very effective communications strategy that includes targeted communication to partners, funders, government, and potential students including potential female students. Communication materials are very good, including a particularly impressive short film on the Centre.

7 Innovation and value creation

The Centre comprises three groups of user partners: oil & gas, physical security and transportation. In total, the Centre's 14 partners constitute a well-structured critical mass sharing generic needs for validated computational tools. The process and pathway from basic research to knowledge transfer for the partners is commendable. It is also commendable that industry has made the effort to articulate its needs to the multidisciplinary research community – three departments at NTNU and SINTEF Industry. However there seems to be further potential for knowledge transfer from the Centre through establishing spin out projects from the Centre with current or new partner constellations. The evaluation team encourages the Centre to go in this direction as part of building a sustainability strategy for the final period. Here, the commercial spinoff company "Enodo" will potentially play an important role in implementation and knowledge transfer, at the same time bridging the gap between cutting edge research and industry.

There are several examples of activities that provide evidence of a well-functioning centre:

- mutual mobility of people between industry and academia
- arranging for Centre PhDs to visit other laboratories or industry for short periods
- user partners being involved in co-publications with Centre researchers as a part of their business strategy to boost confidence in future uptake of Centre software packages.

The Centre is in good position for the coming years to secure knowledge transfer of validated computational tools for future innovations, providing value creation for all partners.

8 Funding and financial aspects

Approximately 75 % of the contribution from user partners is in form of cash. This gives the Centre a very good financial position to sustain a critical mass of projects. It is also noted that the Centre's public partners put in substantial cash to secure the long-term knowledge base.

9 Gender aspects

The Centre has made considerable efforts to promote equal opportunity. But the situation can be improved, and the evaluation team hopes that those efforts are boosted for the final years. In particular we believe that the Scientific Advisory Board can have a better gender balance.

Recommendation 1: That the Centre ensure that its scientific advisory board is gender balanced.

10 Future activities

All Centre partners believe that the Centre should continue in some form after the end of the RCN financing period. It is clear that industry is willing to continue contributing given the likely benefits. Also, NTNU is keen to host a continuation. The Centre and its precursors have a long history of attracting competitive funding, so it is likely that the achievements of CASA can be extended in some form to meet new challenges.

11 Conclusion and recommendations to the Centre

This is an excellent competence centre with many examples of best practice in its research, research training, organisation, and industry support operations. However, it could improve its gender balance especially in its high-profile committees. Accordingly, our recommendation is as follows:

Recommendation 1: That the Centre ensure that its scientific advisory board is gender balanced.

Mary O’Kane (Chair)

Mattias Lundberg

Eric Markiewicz

Mats Oldenburg

17 March 2019

CIUS – Centre for Innovative Ultrasound Solutions

1 Introduction

On 8 April 2019 the evaluation team met with the Chair and members of the Board, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, NTNU. In the morning the discussions focused on the research at the Centre and included a laboratory visit. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. It also has carefully taken account of feedback from the Centre on an earlier draft of this report sent to the Centre for fact checking. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

The centre has three application domains: healthcare, oil and gas, and maritime. The main focus of CIUS is healthcare. The other two areas are smaller raising questions with respect to their critical mass. The Centre argument is that the cross-linking between the three topics is important and interesting. This approach seems to be working as demonstrated by the transfer of CIUS graduates and their hiring by Norwegian industry.

The excellent connection of the research activity to the clinical use of medical ultrasound is a major and particular strength of CIUS. The scientific output of CIUS is clearly shown by the large number of scientific papers and one textbook, and the winning of several research prizes. The consortium ensures it is highly visible by presenting its results at the key international conferences. However, the number of patents secured is low if one considers the number of people involved particularly from industrial collaborators. For the remaining period, knowledge transfer should be put at a higher priority. This would be helpfully demonstrated by patent applications and ultimately successfully negotiated technology licensing agreements. A further minor suggestion is to change the way publications lists are presented in the annual reporting documents, conference papers should be listed separately.

The Centre recognises that there are many activities worldwide where micro-machined ultrasonic transducers (CMUTs and PMUTs) are monolithically integrated directly with CMOS electronics. A particular example is the US Butterfly business that already has FDA clearance for their clinical use. Such companies are in direct competition to the large medical ultrasonic companies (GE, Phillips, Siemens, Hitachi, Toshiba, etc.) and they are also using machine learning techniques. We note that learning expertise is available to the consortium both internally and from NTNU AI capability that is outside the Centre. The Centre should more closely and visibly directly track industry developments.

The 3D flow activities of the Centre are recognised internationally. It raises a minor question of why there is no combination of this work with the Centre's bubble activities? The Centre's approach to measuring the stiffness of the heart is also a promising direction for clinical applications.

The scanners used in the research work show a strong and visible linkage to GE, while scanners from other suppliers are used in the laboratory work. There is a concern that GE dominates some aspects of the work in CIUS and that this may not be in the best interests of the whole consortium.

The low-power ADC being worked on in the consortium is considered by it to be a current world best for low power use and with great potential for the application area if whole systems issues are taken into account. This work is clearly related to and of interest for GE and would be assisted by contacts with knowledgeable ASIC designers within the company (for example to establish whether High Voltage on the ASIC is required, this is unclear with 28 nm technology). This would have the benefit of increasing the critical mass in the area and reduce the risk of the PhD student involved considering himself isolated.

Nonlinear imaging (higher harmonics) in seabed mapping (200 kHz TX, 400 kHz RX) uses both the pulse-echo method and a synthetic aperture approach. Given the need for high resolution images, harmonic imaging is important. The consortium should consider developing larger aperture transducers.

Mainstream approaches in adult cardiac ultrasound imaging have traditionally carried out analysis afterwards (measuring the ejection fraction by segmentation of the left ventricle during the cardiac cycle). The centre's automatic segmentation approach is now working in about 90% of patients, is real-time and the ejection fraction can be immediately displayed. Importantly this gives direct feedback for the operator. This is an important innovation.

A new feature on the GE machine is vector flow imaging of the flow inside the left ventricle. In congenital heart disease in children imaging the flow pattern within the left ventricle and outflow tract with this approach gives much more information than conventional Doppler. Important clinical studies are on-going in the Centre to prove the usefulness of this approach.

It is particularly positive that there are two start-ups (ReLab and Cimon Medical) already engaging in the Centre with a third (NiSonic) being invited to join the Centre. These partially originate from CIUS and from SINTEF. CIUS have also helped start-ups within other grant applications. In the discussion the Centre was helpfully clear on where the patents core to the activities of the start-ups had originated and whether this was within CIUS.

The academic partners have long-term experience in performing research with industry. The consortium includes small and large companies from maritime sonar, medical, and oil and gas sectors. The collaboration in the medical field is a long-lasting one that dates back to the early seventies, to the early years of real-time medical ultrasound. GE stated that such a long-term relationship is essential to building up mutual trust. While Equinor (Statoil) have only had a short relationship with the CIUS group, they also stressed that such a long-term relationship is essential - years of talking is required to "understand" each other's language.

The research profile of the work package leaders is appropriate to the work content, particularly in the medical field but perhaps is less immediately apparent for the new areas of sonar and oil and gas (work packages 8 and 9). Significantly the leader of these work packages acts as an intermediary between the three sectoral pillars and the industrial partners. The consortium is happy with this approach as importantly it permits knowledge transfer between the sectors and to the none healthcare partners.

Recommendation 1: The Centre should more actively and visibly directly track trends in the industry including emerging alternative and disruptive transducer technologies.

3 Internationalisation

The researchers at the Centre actively attend key conferences. This is an important mechanism for extending their network to other research groups and gives the opportunity to establish international two-way researcher and PhD student exchanges. Company partners may have concerns about knowledge leakage by such exchange activities, the reviewers however consider that it is key to maintain a high level of exchange. There is one company partner from outside Norway (X-Fab, Germany).

The number of international senior researchers within the Centre is perhaps low. There are opportunities to leverage EU funding programs, such as Marie Curie Fellowships, to increase this. The Centre clearly attracts international PhD-students by offering good research topics within in a good equipment infrastructure, in particularly in the field of medical imaging.

Recommendation 2: The Centre should more actively pursue EU grants to assist individual researcher mobility.

4 Researcher training and engagement in education

It is excellent to see that medical doctors are participating in the PhD program and this forms an important part of the Centre's practical clinical interface. It is also positive that there are students directly located on company sites. Students report that there are regular weekly meetings with the faculty and the other PhD students at the Centre. The students see that a clear benefit of the Centre is the interaction with a large group of researchers and with companies. The students however, indicate that there is little direct contact with companies, such as GE, other than in project meetings. There is a clear procedure for approval of publications by companies. It is good to see that there are two 2-day meetings per year for all the students, so they can get to know each other better, socialise and also interact with industrial partners. However, the three year time limit for science and engineering PhD's is problematic in comparison with other international practice for applied research. The scientific training requirements and expectation that students contribute to three journal papers leave little room for the industrial and international experience that is necessary to properly develop internationally competitive applied researchers.

Recommendation 3: The Centre must put more effort into securing industrial and international research placements for its PhD students and consider alternative models to the three year programme that are permissible under the RCN funding.

5 Plans for final three-year period

The Centre have developed guiding principles to shape their final three-year period. In particular they will ensure that each Centre partner is allocated a PhD student project and that they will focus unallocated resources on projects that have the greatest commercial value. Discussion at the review noted that the industrial partners are best equipped to make decisions on future commercial value. The Centre are also actively recruiting new industry partners. Plans in oil and gas and maritime are not as well developed as those in healthcare.

Recommendation 4: The Centre requires a clearer strategy for its work in oil and gas, and maritime. This is especially important given that the Centre recognises the power of working in a cross-sectoral way and that this could be central to a successor SFI bid.

6 Organisation and Management of the Centre

The centre is highly visible internationally and has a strong identity especially in healthcare. It is high performing and well managed, both by the Board and day to day. Communications between the academic partners in the centre are good. Industry links are strong, but strongest in the healthcare sector. The Centre is important within the host institution and seen as the model for excellence in innovation for NTNU. Industry particularly recognised the value of the Industry Liaison role. The recent ISAB commented on the scale and complexity of the Centre and the requirement for additional administrative report.

Recommendation 5: The Board is encouraged to work in a way that recognises that Board members represent the interest of the whole Centre as well as the interests of individual industrial partners.

Recommendation 6: The review panel endorse the observation of the recent ISAB that the centre requires more administrative support and consider that the host institution should allocate more administrative support to assist the work of the Centre.

7 Innovation and value creation

The Centre covers three different end user domains represented by 17 partners. There are 11 private companies, 3 hospitals and 1 regional health authority. The largest stakeholder representation is from the healthcare value chain. The resources from healthcare form approximately 50% of the total contribution from industry and others. The overall direct contribution of the oil and gas industry is approximately 30% (derived from the budget tables presented for the final 3 years). The evaluation panel was surprised, both from the written material and from the discussion, that the activity so far within work packages 8 and 9 has been comparatively minor to date and that there is not yet a clear plan of activity in these areas in the final period. The panel was however reassured that the oil and gas partners have a clear goal for the Centre and will take benefit from the Centre. This was less apparent with respect to the maritime partners but it is clear that important and challenging problems in the domain are now being identified. The evaluation panel consider that such plans should be further clarified in the near future to establish more clearly defined projects in work packages 8 and 9.

We commend the Centre for its approach to securing knowledge implementation in the clinic including ensuring best fit with clinical practice and clinical pathways. We also strongly support and commend the Centre in its efforts to recruit new partners.

Unfortunately, it was difficult for the evaluation team to clearly identify the number and value of associated projects directly and explicitly originating from the results of the current Centre. This is important as it gives a clear picture of the Centre impact to the partners, funders and most importantly potential future partners. The board is encouraged to clarify this. This should be taken forward in combination with efforts to increase associated projects and other activities in order to sustain Centre activities beyond the 8 year period. This should include enhancing linkages with current partners and as well as growing them with new potential partners.

The number of Master theses enabled by the Centre is excellent. However, the Board and partners should act more proactively to identify topics in order to ensure broad knowledge transfer to all partners. The masters project approach can also act to assist the recruitment of the under-represented sex. This also contributes improving equal opportunity in the future by permitting the partners to get early access to either PhD candidates or candidates for direct recruitment.

The mobility of PhDs in healthcare is good, but in the other domains the Centre should seek more opportunities for industrial mobility. We encourage all partners to find ways to increase this for all science and technology PhDs. This is an important tool for knowledge transfer.

We also commend the centre for its clear strategy on IPR and the reporting of DOFI. This shows clear potential knowledge transfer to user partners. The evaluation panel supports the Centre aim that all partners will get impact from the Centre. We consider that the board will need to work to secure this for the final period of the Centre.

8 Funding and financial aspects

The Centre is very well financed. We note that this comes from all partners / stakeholder and gives a total turnover of 69 MNOK in 2019. This shows not only the large scale of the research activities but also the real interest from user partners, especially within the healthcare domain. The recruitment effort to add more partners to the Centre will make it even more visible on the global map. The evaluation panel however have some concerns with respect to the in-kind contributions from the oil and gas and maritime sectors. Given the current low activity in work packages 8 and 9 it is unclear whether both this in-kind effort will be committed and correspondingly that the partners will secure real knowledge transfer. This needs to be urgently clarified as part of the planning recommended in Recommendation 4.

9 Gender aspects

Awareness of equal opportunities issues is good in the Centre on many levels. However, the evaluation panel was particularly disappointed to see the missed opportunities, both the short term and long term, to transform this awareness into clear actions.

We encourage the Centre to identify those opportunities/actions that need to be implemented as matter of urgency to change the poor statistics for the Centre. This should start immediately with the recruitment of master students with the identification of relevant and attractive topics for Master theses and PhDs. There is also a need to encourage female students at all levels to be better connected to the industry, for example by a mentoring program with mentors from industry spanning the entire value chain. There is no doubt that this will assist in securing scientific and industrial impact and help the industry to be more competitive in the future.

The Centre has the opportunity to act as a long term change agent. The Centre will be able to find both inspiration and proven best practice approaches, such as champions and mentoring, by discussions with other centres.

Recommendation 7: The Centre should put more effort into addressing its gender balance issues. These include adopting best practice mentoring models used by other Centres and increasing its focus on engaging promising masters students.

10 Future activities

The Centre has a clear ambition to bid for a follow-on SFI Centre with a similar remit and that continues the cross sectoral approach pioneered in this Centre. Industry partners from all the sectors represented at the review emphasised the value of sustaining the long-term relationships built in the Centre.

11 Conclusion and recommendations to the centre

The Centre is impressive. It is high performing and well managed with good industry links. It has clear international excellence in medical ultrasound imaging. However, results in oil and gas, and maritime are only now emerging.

The review panel makes the following recommendations:

Recommendation 1: The Centre should more actively and visibly directly track trends in the industry including emerging alternative and disruptive transducer technologies.

Recommendation 2: The Centre should more actively pursue both EU project and ERC personal grants for individual researchers.

Recommendation 3: The Centre must put more effort into securing industrial and international research placements for its PhD students and consider alternative models to the three year programme that are permissible under the RCN funding.

Recommendation 4: The Centre requires a clearer strategy for its work in oil and gas, and maritime. This is especially important given that the Centre recognises the power of working in a cross-sectoral way and that this could be central to a successor SFI bid.

Recommendation 5: The Board is encouraged to work in a way that recognises that Board members represent the interest of the whole centre as well as the interests of individual industrial partners.

Recommendation 6: The review panel endorse the observation of the recent ISAB that the centre requires more administrative support and consider that the host institution should allocate more administrative support to assist the work of the Centre.

Recommendation 7: The Centre should put more effort into addressing its gender balance issues. These include adopting best practice mentoring models used by other Centres and increasing its focus on engaging promising masters students.

David Williams (Chair)

Nico de Jong

Mario Kupnik

Mattias Lundberg

11 May 2019

SUBPRO – Subsea Production and Processing

1 Introduction

On 3 April 2019 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives, postdocs, PhD students, and representatives of the host institution, the Norwegian University of Science and Technology (NTNU). In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

Research activities in the overall project involve 43 PhD and postdoc researchers, distributed into five homogeneous research areas, under the supervision or co-supervision of 21 professors and adjunct professors (20 %) from the industrial partners, with a very well defined scientific research programme. SUBPRO is the largest academic subsea research and innovation centre worldwide with around 100 people including MSc students (around 20 each year) under the supervision of PhD candidates.

The research activities were well organised within the five research areas from the very beginning of the SUBPRO project. As a result, after only three and a half years, 12 projects have been completed, and 58 peer-reviewed and 63 conference papers are already published. These numbers together with the clear focus on the research areas (field architecture, RAMS (Reliability, Availability, Maintenance and Safety), separation characterisation and new concepts, and system control) confirm that the Centre has already achieved a critical mass and international recognition. Research projects cover the wide field from fundamental understanding, through concept, methods and tool development, to testing and verification at a laboratory scale, e.g., as seen during the evaluation team's visit to the Multiple Parallel Pipe Separator prototype, where the Technology Readiness Level of 3 (on a scale up to 9) has been achieved. Excellent results were obtained in each research area and the first seeds of cross-fertilisation are already present. Collaboration is active with both industrial partners and more than a dozen highly ranked international universities.

The Centre is now entering a new phase of an even closer collaboration with industrial partners and a clear intention to involve industry engineers with relevant experience in both project definition and supervision. The evaluation panel supports this orientation and the multiple exchanges during informal meetings and reference group meetings that bridge the gap between industrial needs and academic approaches. This might result in new projects with natural involvement of academics from different research groups and strong interest of industry partners; eventually resulting in an increased level of innovation as required by the SFI scheme. In preparing for this final phase, the Centre would benefit from a critical evaluation by the Scientific Advisory Committee (SAC) (see Recommendation 1). Ideally it will meet in Trondheim together with the Centre Board, Director, adjunct professors, research area leaders and PhDs and postdocs.

There are still gaps in knowledge and technology, e.g., in separation at high pressures, that would lead to significant improvements in the implementation of subsea units for production and

processing and associated societal benefits. As a result, we are confident that the industry need for the Centre's research will continue beyond the end of the current funding period.

3 Internationalisation

There is a rich diversity in the cohort of PhD and postdoc recruitment (including 14 nations) and the Centre collaborates with over 12 highly ranked foreign universities, through research visits (duration from 2 weeks to 12 months) involving PhD students and professors. Some visits are directly funded by the Centre others are part of the three year International INTPART Brazil-Norway programme. Visits or work periods in international research groups are encouraged and supported by the Centre. Connections exist not only with foreign universities but also with major oil companies.

Among the 12 finished and 15 running research projects, all those who wish to develop their skills through a research visit outside NTNU are strongly encouraged providing the quality of their research project is adequate. Such visits typically result in co-authored publications. The Centre might encourage even more PhD students to take at least three month visits within internationally recognised partner universities with a potential benefit of an extended PhD content (keeping within a three years duration) and international experience that is valued by industry. Such a policy could be applied from the definition of a PhD project and might result in increasing attractiveness for prospective researchers.

4 Researcher training and engagement in education

The PhD students and postdocs who met with the evaluation team were impressive both individually and as a group. Several had secured jobs in industry for after their graduation before they had submitted their theses. They articulated very clearly the many benefits of being in the Centre, including opportunities for industry collaboration, group site visits, international exchanges and social activities. The Centre is commended for its strategic initiatives to increase the capacity of students to transfer knowledge to industry, e.g., through the innovation projects. All of the students we met were involved in the education of Master's students and were enthusiastic about their opportunity to do so. Several of the students expressed an interest in further training in subject areas such as project management and the industry value chain. Overall, PhD and postdocs are very well educated and prepared for employment in the industry in Norway as well as abroad.

5 Plans for final three-year period

The Centre has clear criteria for the selection of research projects that will be delivered in the final three years. These have been designed to ensure that all projects include at least one industry partner and two SUBPRO research areas, each providing a co-supervisor. To ensure the scientific quality of these projects, the SAC should be included before their definitions are finalised and so should meet before the end of 2019. This meeting should also include strategic discussions that cover plans for after the current funding period. In addition, the SAC should produce a single report that reflects their combined view of the Centre's science and research environment.

Two associated research projects within individual research areas have been identified in the first period along with two international projects: INTPART (a Brazil-Norway Subsea Operations consortium) and SAFETY 4.0. In addition, the evaluation team noted that two PETROMAKS projects are under review with RCN. For a Centre of this size, the evaluation team would expect to see more associated projects at this stage.

Recommendation 1: That, before the next tranche of PhD projects is finalised, the Scientific Advisory Committee meets as a group with the Centre to inform the definition of the projects for the final three year period and the strategy for sustaining the Centre after the funding period.

6 Organisation and Management of the Centre

The scientific capacity of the seniors, all of whom are recognised international researchers, is excellent and the Centre is strongly supported by the host institution. The leadership is well structured with a director and co-director who work as a highly effective team supported by an excellent management and administration team. The Board is very dedicated and well connected to the core science and the management team. The organisation reflects industry best practice and needs with a technical committee bringing together outputs from the reference groups before they are referred to the Board. The reference groups themselves are an effective way of transferring knowledge between researchers and industry, to both review research outputs and identify new projects, and to share data and other resources, e.g., samples of crude oil. NTNU intends to allocate 40 % of a new innovation manager to the Centre; the role of this person in the Centre needs to be clarified with the Board.

The quality of the external communications of the Centre, including all of the annual reports and the web site, is also excellent. This enhances the visibility and identity of the Centre with industry, but the full scale of the Centre's capacity would be improved by reporting all in-kind contributions (see Recommendation 2) and being more prominent in international academic arenas such as the planned participation in the Subsea Valley Conference 2019.

7 Innovation and value creation

The industry partners cover both operators and service providers who act as suppliers to the operators. Although the Centre's research covers a wide range of topics relevant to subsea processing and operations, and it is delivered through 43 projects, the partners are proactive and enthusiastic in identifying new knowledge from the Centre and how it might be translated into innovations. Mechanisms for mutual mobility of personnel are in place with, e.g., students spending periods in industry and adjunct professors being appointed on a part-time basis to the host. An area for improvement would be in striving for more co-authored papers between researchers and industry.

The development of the innovation project mechanism, with a three month period for knowledge transfer at the end of PhD projects where the student is a member of staff of the host, which is written into the PhD project definition and so students' contracts, is a positive step forward. In addition, partners share data and materials in a very open way and the reference groups provide opportunities for detailed discussions between researchers and industry partners. The Board has agreed on a policy that prioritises publication of results over the development of patents but there is a process in place, managed through the Technical Committee, to provide all partners with details of results on a weekly basis that offers a 60 day window for patent opportunities to be identified.

8 Funding and financial aspects

This is a large Centre built on a stable financial basis that includes a large proportion (47%) of cash from industry. The financial contributions from industry are reported as cash but in-kind contributions are not included. As a result, the research and innovation capacity of the Centre, measured by its financial power, is underrepresented in the total annual budget because there are

substantial in-kind contributions from partners. These should be reported in a way that minimises the administrative burden on the Centre or its partners. However, it is important that the full scale of the Centre is visible for the final period and beyond.

Recommendation 2: That the Centre ensures the in-kind support from all partners is included in financial reports.

9 Gender aspects

In the light of the history of this field, the gender balance is very good across all levels.

10 Future activities

Discussions in the Centre on a strategy for ensuring its sustainability after the funding period are at a very early stage. This was surprising given the time needed to gain funding to maintain the capacity that has been built up in both the host and industry partners. One example of a way to do this is to identify and develop associated projects that arise from the Centre. The continuity of the Centre at the end of the funding period will depend on the success of proposals for such projects. This success is likely to include the recruitment of additional partners and identification of new application areas which, in turn, will depend on the Centre increasing its visibility in international research networks.

11 Conclusion and recommendations to the Centre

The Centre has very impressive dynamics in and across each of the five research areas and a well-defined structure in three reference groups. In addition, the industry partners are very well engaged with the Centre. The leadership, management and administration are all strong. This mid-term evaluation has however highlighted two areas which could be improved further and accordingly our recommendations to improve the Centre are as follows.

Recommendation 1: That, before the next tranche of PhD projects is finalised, the Scientific Advisory Committee meets as a group with the Centre to inform the definition of the projects for the final three year period and the strategy for sustaining the Centre after the funding period.

Recommendation 2: That the Centre ensures the in-kind support from all partners is included in financial reports.

Alison McKay (Chair)

Hervé Carrier

Mattias Lundberg

Krzysztof Wolski

17 April 2019

Centre for Offshore Mechatronics

1 Introduction

On 14 March 2019 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives, postdocs, PhD students, and representatives of the host institution, University of Agder. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

The research within the Centre is organised in six well-structured work packages, each connected to a reference group consisting of several representatives from the industry partners active in the area. Most of the WPs have clearly stated objectives towards applicability in the offshore context. During the presentation the Centre emphasised that its ongoing research covers a broader scope of offshore applications than in the traditional oil & gas industry, and that this is supported by the Industry partners. Thus, its application areas include wind farms and fish farming, recognizing a national need for Norwegian industry to continue to expand beyond offshore oil and gas.

The Centre's research has been reported in a substantial number of peer-reviewed contributions to internationally well recognized conferences and journals, which together with the stability in the WP leadership and the close operational collaboration with the project management, constitute important key performance indicators during the period. Whereas a majority of the presently published research outcomes are 'Level 1'-papers, it could be expected that the number of 'Level 2'-papers will increase as several of the PhD students are soon to defend their thesis work. The Centre currently has three Level 2 papers accepted, and an additional five have been submitted so far in 2019.

There has been a very active initial period of building and improving laboratory facilities among the research partners which is vital for the continued research and experimental validation with both prototypes and full scale testing, including outdoor experiments to address harsh offshore environments. This gives excellent conditions for efficient knowledge and technology transfer in modularised units for integration and use of research at the industry partners.

The interactions between the research tasks within the individual work packages, some based at different campuses, have been enhanced by the broad interest in these areas by Norwegian companies.

Some WPs have already, in the initial phase, had close research collaboration with obvious synergies of shared supervision/co-supervision. Further integration across the WPs based on the derived models and simulation environments is expected to be most beneficial for the project and is endorsed by the evaluation team.

The recruitment strategy of actively employing some of the PhD students with previous industrial background brings important experience to the Centre.

The research within the Centre has already created a substantial number of spin-off projects.

Whereas some WPs cover research topics which connect tightly to industry partners' traditional R&D, and therefore may be more direct to incorporate into firm-led innovation, hands-on workshops and dedicated actions for technology transfer regarding, e.g., data analytics and predictive maintenance may be important means for the dissemination of wider research findings from across the Centre.

Overall the evaluation team was impressed with the Centre's research and its applications for the offshore mechatronics industry but suggests that the Centre is not yet fully communicating its strengths nor is it disseminating its research findings adequately across all its industry partners through specialist education and training.

Recommendation 1: That the Centre facilitates external communication of the excitement behind the research and the innovation potential for industry, including considering the establishment of one or more umbrella/showcase technology demonstrator projects that draw on the findings from multiple WPs. In communicating the excitement, particular attention should be paid to communicating in ways that help address the gender balance within the sector.

Recommendation 2: That the Centre increases the impact of its research findings to the industry partners by increasing the industry-focussed education and training, including through increased production of user manuals, digital learning resources, training videos and other activities.

3 Internationalisation

The Centre successfully engages in cooperative international research activities. Students have presented numerous papers at international conferences; articles have been published with international co-authors from the USA, Denmark, Greece and the Czech Republic. The Centre has collaborative international partnerships with Aalborg University in Denmark, RWTH Aachen in Germany, Bosch Rexroth in Germany and the Netherlands, and Klueber Lubrication in Germany. Other activities such as sabbaticals, guest lectures and visits have involved Rice University in the USA, Karlsruhe Institute of Technology in Germany, and Lund University in Sweden. One of the Centre's post-docs is from Spain, and a reasonable number of the Centre's PhD students are international including students from Denmark, Germany and Brazil. Centre personnel are playing a key role in organizing the IEEE Conference on Industrial Electronics and Applications to be held in Kristiansand in June 2020.

4 Researcher training and engagement in education

Each research project is supported by a work package reference group with members drawn from the Centre's industry partners. The PhD students found this industry engagement to be a beneficial educational experience and valuable practical input to their research. Students interviewed expressed a high level of satisfaction with their choice of pursuing PhD-level education in the Centre. The Centre now has been in place long enough that current PhD students have significant experience and are in a position to serve as mentors for incoming students. This opportunity will grow as some current PhD students transition to postdocs. In many cases, students work closely with students in other projects or work packages; in other cases, students could significantly benefit from more interaction between projects.

Recommendation 3: That the Centre creates more opportunities for PhDs and postdocs to interact across WPs and so gain the added benefits from belonging to the Centre as a whole.

5 Plans for final three-year period

The Centre is currently operating with a high level of activity and is making excellent progress with respect to the original work plan. It seems likely that only minor adjustments will be needed in the final three years. Many current PhD students will graduate in 2019-2020, and the Centre is actively recruiting new PhD students. The project management team is strong and is likely to remain stable during the final three years. Several of the graduating PhD students may continue as postdocs or remain involved in the Centre as employees of participating companies, which is viewed as very valuable knowledge transfer.

6 Organisation and Management of the Centre

The Centre has good visibility within the industry partners that is achieved through a number of mechanisms. These include reference groups associated with WPs 1-6 that were seen as a particularly effective way in which industry partners can influence the research and through which PhDs and postdocs engage with industry. In addition, the annual Centre gathering is used by partners to expose the Centre's activities to a wider range of employees than those involved in the reference groups. The Centre's web site is visually clear, easy to navigate and the level of information provided is very good.

The Centre director provides a highly effective form of proactive leadership and management that capitalises on the strengths of all partners. Strong evidence of this lies in the stability in the WP leadership (there have been no changes since the inception of the Centre) and the fact that all of the original partners have remained in the Centre despite the significant downturn in the sector in 2015. At the interview, all partners were positive about the performance of the Board and management of the Centre. There are direct lines of communication between the Board and both the International Advisory Board and WP7 (Technology Vision). The IAB provides feedback directly to the director but not a written report that can be shared more widely.

The Centre is the first SFI centre at the University of Agder (UiA) which provides excellent facilities for the research activities, e.g., through its Mechatronics Innovation Lab. There is close alignment between the Centre's research and other research and educational programs at UiA.

Recommendation 4: That the Centre revises the way it works with its International Advisory Board (IAB). The IAB, which should be gender balanced, should meet annually and formalise its advice through an annual written report which can be shared across all partners and bodies associated with the Centre and used as a useful input to the annual planning process.

7 Innovation and value creation

The Centre's approach to innovation and value creation is very good, especially as many of the industry partners are competitors. At the interview, Centre partners highlighted several mechanisms that had been used effectively to achieve this including:

- ensuring the Centre research is relevant to industry partner needs by involving industry partners in the whole project lifecycle from application to commercial uptake;
- delivering research results in forms industry partners can take up easily for their own commercial purposes;

- having lively reference groups for each Work Package predominantly comprised of industry partner representatives;
- recruiting several PhD candidates from industry partners;
- industry partners employing Masters and (soon) PhD graduates (and, it was noted, they want more);
- industry partner representatives being active in the General Assembly, the Steering Board and in co-supervising PhD students;
- industry partners using the Centre Day as a chance for their staff to become familiar with latest research developments;
- producing patents, although only a small number at present;
- restructuring WP7 in 2018 to focus on closer dialogue between all work packages and industry.

The Centre also highlighted where it could do even better in assisting its industry partners to innovate through increasing specialist education/training materials such as training manuals (See Recommendation 1 above) and through using the PhD students likely to graduate soon becoming co-supervisors on new PhD projects. The evaluation team endorses these initiatives.

8 Funding and financial aspects

The Centre has sound financial management. Most partners contribute both cash and in kind to the Centre. Many of the partners have also contributed to the Mechatronic Innovation Lab (MIL). This provides excellent research infrastructure that the Centre uses for key experiments.

The Centre complements its core funding with funding channelled through spin-off and associated projects. The Director indicated that the Centre intends to ramp up its focus on attracting EU/EEA funding during 2019-22.

9 Gender aspects

As the Centre acknowledges, gender balance is a challenge for it and for its industry sector. A particular issue is attracting female PhD students when there are very few in the relevant, local undergraduate and Masters pools. The only current female PhD student was attracted by the offer of an integrated Masters/PhD program, a sensible initiative. We encourage the Centre to communicate the excitement associated with the Centre's activities, including focus areas such as energy efficiency, in forums that will attract the attention of potential female PhD students including from other countries (see Recommendation 1 above). We also suggest that the Centre ensures that all organisational structures in the Centre are as gender balanced as possible, hence the recommendation (Recommendation 4) that the International Advisory Board be gender balanced.

10 Future activities

At the interview, plans for the development of a post-2022 strategy were discussed. We would encourage the Centre to prioritise this and, in doing so, consider more potential application areas for the research. In addition, as identified in the interview, the Centre should consider wider industry needs for the creation of value from the research, e.g., by including disciplines that could address more business oriented needs such as contractual issues.

11 Conclusion and recommendations to the centre

As a competence centre supporting offshore industries, the Centre is performing well, with good industry engagement and effective leadership.

This mid-term evaluation has however highlighted areas which could be improved further and accordingly our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre facilitates external communication of the excitement behind the research and the innovation potential for industry, including considering the establishment of one or more umbrella/showcase technology demonstrator projects that draw on the findings from multiple WPs. In communicating the excitement, particular attention should be paid to communicating in ways that help address the gender balance within the sector.

Recommendation 2: That the Centre increases the impact of its research findings to the industry partners by increasing the industry-focussed education and training, including through increased production of user manuals, digital learning resources, training videos and other activities.

Recommendation 3: That the Centre creates more opportunities for PhDs and postdocs to interact across WPs and so gain the added benefits from belonging to the Centre as a whole.

Recommendation 4: That the Centre revises the way it works with its International Advisory Board (IAB). The IAB, which should be gender balanced, should meet annually and formalise its advice through an annual written report which can be shared across all partners and bodies associated with the Centre and used as a useful input to the annual planning process.

Alison McKay (Chair)

Neil Duffie

Mary O’Kane

Anders Robertsson

20 March 2019

SIRIUS – Centre for Scalable Data Access

1 Introduction

On 18 March 2019 the evaluation team met with members of the Board, the Director, project leaders, PhD students, post-docs, representatives of the host institution, and representatives of the industry partners. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

It was clear from the thoughtful material presented at interview that the Board and management of the Centre had used the mid-term evaluation and their own recent internal review to reflect effectively on what had and what had not worked well and, on the basis of this, their priorities for 2019, and, in a limited way, their strategy beyond this.

2 Research activities

Team Composition: The centre has a good balance between senior researchers and a new generation of emerging talent. The research program is focused on the core topics necessary for scalable data. The centre has transitioned from three research strands to a matrix structure with research programs and beacon projects. The panel welcomes this reorganisation as it is more scalable and helps to structure the competency and the project work along the TRLs. This reflects the fundamental complexity of the challenge for SIRIUS. In terms of size, each of the groups are balanced.

Partner Roles: The different academic partners all have clear roles and are contributing a clear competency to the centre. The centre effect was much more visible from the presentations.

Core Topics and Relevance: The theme of the centre is large-scale data access, and the core research programmes of SIRIUS are aligned with the core needs: semantic integration, ontology engineering and scalable computing. These groups are broadened with the inclusion of expertise on data science, analysis of complex systems, and industrial digital transformation. Together the relevance of the centre to industry is at the intersection between these different topics.

Collaboration with Industry: Within the projects highlighted in the review process there is a high-level of engagement from the industrial partners. The panel noted that the projects focused on engagements with larger industry partners. The centre is encouraged to engage more SMEs within the work program. The current work program has a large number of smaller projects (~35 projects) and there is a danger of fragmentation. The panel acknowledge that the beacon project structure is a step to address this concern, however each beacon has a number of sub-projects that look to be funded and managed individually. The panel recommend further consolidation of the projects to ensure critical mass and built in synergies, impact, and exploitation.

Joint Industry Publications: The number of joint publications with Industrial partners at the 3-year point of the centre is low. The centre expects the number of joint-industry academia publications to increase significantly in the coming year. The panel recommend this is closely monitored and incentivised.

Research Output: The panel note that the centre has already produced more than 80 publications. This is ahead of their goals of producing 139 publication in 8 years. A number of publications from the centre have been nominated for/won best paper awards at international venues. We expect the research output to increase as the students within the centre start to graduate.

Broadening and Diversifying Research Profile: The established topic at the start of the centre was based on the work from the Optique project on ontology-based data access. The results of this work provided the centre with a solid scientific foundation. As the centre matures it is important for each of the research programs to make clear and industrially relevant scientific contributions beyond the traditional core topics of the centre. The International Scientific Advisory Board should support the development of the new research programs and collaborations.

Keynotes and Tutorials: The researchers in SIRIUS have been recognised with invitations to keynote and have presented tutorials at scientific and industrial events.

Recommendation 1: The Centre should explore to what extent the key methods and tools being developed and applied by the Centre are appropriate to tackling the specific characteristics of industrial problems and application domains. This will have the benefit of both delivering guidelines for their use as well as exposing areas in which they are less effective and where more work is required. This is a significant and academically and industry endorsed area for work by the Centre.

Recommendation 2: As it moves forwards the Centre should carefully consider the range of disciplines that it spans scientifically and with respect to application domains. It should not underestimate the effort required to become competent and internationally differentiated in more distant domains such as healthcare.

3 Internationalisation

Internationalisation was embedded in SIRIUS from its inception. SIRIUS arose from an EU project and it has an inherently international character due to the participation of the Oxford University group. Many of the participating companies are MNCs (for example IBM, Schlumberger and DNV-GL), international companies with global customers, for example TechnipFMC, or are national companies that are internationally active, like Equinor.

The research collaborations mentioned in the documents and presentations and supported by joint publications span European universities and research centres, including Manchester, Bielefeld, CWI in Amsterdam, UWA in Perth and Univ. of Maryland in the USA. A particular role has the collaboration with Brazil: it is aligned with the strategic direction of UiO, with government-led programs in the Gas and Oil industry, and it spans companies (like Petrobras, IBM Brazil and Schlumberger Brazil) as well as UFRGS.

There have been successful and attempted applications to international programs within the EU (e.g. the H2020 MELODIC, EU COST actions), Brazilian funding for travel and research stays (for example sandwich PhDs), and applications to various EPSRC funding programs related to the UK component of SIRIUS, showing a good level of integration in the international networks and a good level of proactivity of the participants.

The collaboration with international research groups has happened so far mostly within the Computer Science specialties of the research groups, with good to excellent results and publication levels. Several PIs are well respected senior members of the international research community, they frequently give keynotes, tutorials and presentations to the scientific community and regularly

organize events co-branded by SIRIUS (see for example iFM in Bergen in December 2019 among others).

The overall approach to internationalization and international collaborative fundraising seems so far opportunistic and mostly driven by the personal relations of individuals. A systematic approach is likely to be more helpful, especially for partnerships beyond the Computer Science core competences and the international Oil and Gas Industry.

The level of internationalisation in recruitment is very high, with many PhD students coming from EU states and outside the EU. Several young as well as established faculty members have an international background, including several Research Program leaders. The Centre has shown to be capable to attract and leverage the international community and has started to establish an internationally recognised brand.

4 Researcher training and engagement in education

MSc Projects: The panel supports the centre in their plans to engage MSc students within projects with their industry partners. This presents a significant opportunity to enhance the educational experience of the students by exposing them to real-world problems and data. Well-designed MSc projects can solve both an industrial need and support the SIRIUS research programmes. They can provide a significant resource to the centre (50 MSc projects) and improve the mobility of skills to industry when the students graduate.

Mentoring Programme: The mentoring activities for early career researchers at SIRIUS are excellent. The centre has leveraged the programmes run by the University (i.e. FRONT) and developed their own 1-on-1 mentoring programme for staff development. The panel were very impressed with the SIRIUS Mentoring Program and believe it should be adopted as a best practice for all SFI centres.

Domain-Specific Training: The centre should regularly re-run domain specific training for new staff members joining. These activities can be broadened to support connections between the students/post-docs and the employees of the industrial partners (i.e. brainstorming workshops).

Researcher Track: The panel acknowledges SIRIUS's contribution to the student "research track" in the department to encourage students to pursue a career in research.

Recommendation 3: The Centre should allocate some of its resource to allow "bottom-up" initiatives driven by its Early Career Researchers (i.e. PhD Students and Post-docs). Such initiatives could include industrial site visits, scientific workshops such as Summer Schools, and mechanisms for welcoming new researchers to the Centre. This could be managed by an elected ECR Committee that made proposals to higher level Boards.

5 Plans for final three-year period

Following its re-organisation, the Centre has a model for its operation as presented by the Centre on a page slide. This captures its activity as a matrix and this, with the detailed project descriptions, gives a good perspective of the balance of the work in the Centre.

As was communicated at the review, the review team have concerns about the level of effort required to become competent and internationally differentiated in domains such as healthcare. It would be much more appropriate for the Centre to focus harder on "early wins" that communicate their value and long term potential value to industry in the oil and gas domain and to carefully

consider the development of an alternative work package that addresses better understanding the fit of the tools being developed to industry problems and application domains.

The Centre must also expect and plan for more dynamism in its activities as it gets closer to industry.

6 Organisation and Management of the Centre

While the Centre has an identity and is visible to the industrial partners, there is an opportunity to better articulate and communicate the Centre Vision to internal and external stakeholders building on the work done for the re-organisation and the review. This should include an industrial perspective on the value added by the Centre. The Centre summary on a page is a useful document that could be improved to be more externally friendly. Such an improvement should also reflect the level of effort in each area and any un-allocated capacity.

Leadership appears shared and consensual. The Centre is operationally well-managed, and all research partners are actively engaged. There have been some astute appointments from industry and young stars are emerging. Host institution support is appropriate, and the institution should consider enhanced support of those areas that are seen as institutionally strategic and not closely aligned with the oil and gas industry. Governance of the Centre is complex, with a further Innovation Board being added to the current structure. The Centre should consider whether its Governance structure could be simplified. Consideration of changes to Governance should ensure that there is appropriate and visible industry representation on the committee (the Strategy Board currently) that explicitly makes funding decisions. As discussed above the Centre should have an International Advisory Board Meeting as planned in 2019 and this Board should be gender balanced.

Recommendation 4: There is an opportunity to better articulate and communicate the Centre Vision to internal and external stakeholders building on the work done for the re-organisation and the review. This should include an industrial perspective on the value add from the Centre. The Centre on a page is a useful document that could be improved to be more externally friendly and such an improvement should also reflect to level of effort in each area and any un-allocated capacity.

Recommendation 5: Governance of the Centre is complex, with a further Innovation Board being added to the current structure. The Centre should consider whether its Governance structure could be simplified. Consideration of changes to Governance should ensure that there is appropriate and visible industry representation on the committee (the Strategy Board currently) that explicitly makes funding decisions.

Recommendation 6: The Centre should have an International Advisory Board Meeting as planned in 2019 and this Board should be gender balanced.

7 Innovation and value creation

The Centre has 13 partners that cover the entire value chain for the long-term digitisation of the Oil and Gas industry. The 13 partners comprise one oil company, 3 service providers and 9 IT companies.

The engagement of the partners with the Centre appears to be good with a high expectation of an impact on their businesses from the Centre especially following the recent re-organisation. However, industry involvement in prototype-, pilot- and innovation projects to date and the industrial impact of projects is less clear. The Centre has a model for technology transfer but again it is less clear how this will work in reality. For instance, we understand that there is more to come, but how many prototype projects, innovation projects and pilot projects will be executed during the final three

years and how will their impact on industry be quantified? The Centre should more clearly and explicitly articulate its goals for knowledge transfer and impact on industry. We encourage the board of the Centre to follow up on this issue carefully.

The dialogue with industry that was carried out during 2018 using the “Partnership Canvas” tool is an excellent initiative. Using this in combination with the re-organisation from Strands to Beacon projects gives opportunities to close the “gap” between research and subsequent implementations of new technology. However, the self-evaluation documents give the impression that there is a range of opinion on the extent industrial partners have secured impact from the Centre. The evaluation team emphasize that this must be improved as a matter of urgency. The main responsibility to secure this improvement lies with the board.

The Centre research in digitalization will certainly have long term impact in different industrial domains. We commend the Centre in its efforts to deliver impact to the core end user and service providers. The panel encourage the centre as a matter of urgency to bring new oil and gas companies into the Centre. As also discussed elsewhere, the evaluation team consider that the healthcare components of WP3 and related connected projects might be distraction to the Centre and that it should stay focused and deliver impact in the oil and gas domain. In addition, we think some of the components of this WP have a low probably of delivering knowledge to end-users as there are no appropriate end-users within the Centre. We believe this component has a better potential for success when progressed via the recently secured associated project with relevant end users within the health care industry. It is also appropriate that any further pump priming work in healthcare is not funded from the core funding of the Centre.

Recommendation 7: The Centre should continue to work hard on improving its relationship with industrial partners, both large and small. This should include using strong existing industrial supporters as advocates. The SFI partner questionnaire process should be rerun in 18-24 months.

8 Funding and financial aspects

The Centre has an annual budget of approximately 42 MNOK/year for 2019 and 2020. When compared to previous years this indicates a slow start. With this budget the Centre has real opportunities to build significant critical mass for 2019-2021. The evaluation panel were also disappointed that industry contributions to the centre are predominantly in-kind. We strongly encourage the Centre to secure cash funding from industry during the final years of the Centre. This will put the Centre in a much better position to deliver clear impact to industry and work in a more dynamic and responsive way.

9 Gender aspects

While the gender balance in the Centre could improve at a senior level, for example via the membership of the International Scientific Advisory Board, we commend the Centre, host institution and its partners for the awareness of and action on equal opportunity issues. These include FRONT, the SIRIUS women’s club, and the SIRIUS mentoring program. There are further examples of good practice from other Centres that the centre could consider implementing with support from the host institution, for instance a small budget for an emergency child care system. The evaluation team are keen that the centre and host institution share their best practice approaches with other research and collaborative environments.

10 Future activities

Plans for continuation of the centre are currently in outline and range from continuing current core activities via large industrially funded collaborations, developing the ECRs in the Centre to a position where they are capable of leading a successor bid, and targeting the Digital 21 SFI opportunity. Given that this review is at a comparatively early stage and following the slow start to the Centre, these plans are at an appropriate level and the centre should emphasise consolidating its industrial relationships and developing its young leaders before considering a refined plan.

11 Conclusion and recommendations to the centre

The centre is beginning to mature and, with the recent re-organisation, has more clarity on its own core competencies and its portfolio, and is well-integrated across the academic and industrial partners. Centre academics are international. It is beginning to deliver knowledge and methods that have clear value for its industrial partners and are additional to the competences developed under Optique. It is also successfully leveraging international activities, particularly those in Oxford. Publications output is ahead of the Centre goals and PhD's are beginning to graduate. SIRIUS researchers are being recruited by industry and industry is keen to recruit Master's students from the Centre.

There are a number of recommendations that the centre should consider as it seeks to further improve its performance and consolidate its activities in preparation for the end of SFI centre funding.

Recommendation 1: The Centre should explore to what extent the key methods and tools being developed and applied by the Centre are appropriate to tackling the specific characteristics of industrial problems and application domains. This will have the benefit of both delivering guidelines for their use as well as exposing areas in which they are less effective and where more work is required. This is a significant and academically and industry endorsed area for work by the Centre.

Recommendation 2: As it moves forwards the Centre should carefully consider the range of disciplines that it spans scientifically and with respect to application domains. It should not underestimate the effort required to become competent and internationally differentiated in more distant domains such as healthcare.

Recommendation 3: The Centre should allocate some of its resource to allow "bottom-up" initiatives driven by its Early Career Researchers (i.e. PhD Students and Post-docs). Such initiatives could include industrial site visits, scientific workshops such as Summer Schools, and mechanisms for welcoming new researchers to the Centre. This could be managed by an elected ECR Committee that made proposals to higher level Boards.

Recommendation 4: There is an opportunity to better articulate and communicate the Centre Vision to internal and external stakeholders building on the work done for the re-organisation and the review. This should include an industrial perspective on the value add from the Centre. The Centre on a page is a useful document that could be improved to be more externally friendly and such an improvement should also reflect to level of effort in each area and any un-allocated capacity.

Recommendation 5: Governance of the Centre is complex, with a further Innovation Board being added to the current structure. The Centre should consider whether its Governance structure could be simplified. Consideration of changes to Governance should ensure that there is appropriate and

visible industry representation on the committee (the Strategy Board currently) that explicitly makes funding decisions.

Recommendation 6: The Centre should have an International Advisory Board Meeting as planned in 2019 and this Board should be gender balanced.

Recommendation 7: The Centre should continue to work hard on improving its relationship with industrial partners, both large and small. This should include using strong existing industrial supporters as advocates. The SFI partner questionnaire process should be rerun in 18-24 months.

12 Recommendations to RCN

Recommendation: Encourage the dissemination of the excellent mentoring and diversity approach demonstrated in SIRIUS across all the SFI Centres.

David Williams (Chair)

Edward Curry

Mattias Lundberg

Tiziana Margaria

10 April 2019

SFI Manufacturing

1 Introduction

On 21 March 2019 the evaluation team met with members of the Board, the Director, work area leaders, PhD students and a post-doc, representatives of the host institution, and representatives of the industry partners. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews, on the written report and self-assessments supplied beforehand and on more detail on publications requested at the review and subsequently provided by the Centre. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

The SFI Manufacturing Centre is organised around three focus areas named RA1-RA3: RA 1 is Multi-material products and processes, RA2 Flexible and robust automation and RA3 Innovative and sustainable organisations.

RA1 covers the fields of Additive manufacturing, multi-material products of both metallic and polymer based materials and multi-scale material modelling with focus on aluminium-steel joining phenomena. From the work done so far it appears that this RA has developed a critical mass of knowledge as reflected in the impressive number of publications and spin-off projects. The plans for 2019 and beyond focus on additive manufacturing which is in line with expectations of Norwegian industry partners in the Centre and current trends. The results so far have been produced by 5 PhD students and 3 Masters students. A research topic that should be considered by the work area is surface texturing and coating to control surface properties for multi-material bonding. Furthermore, RA1 should more deeply address the environmental issues associated with multi-material products perhaps in collaboration with RA3.

RA2 focuses on robotic applications addressing software architectures, methods and algorithms, and integration of hardware and software components at the robot/process and cell level with limited effort at the factory level. However, real industrial pull in terms of the digitalization of industrial operations seems to be missing. The evaluation panel consider that there is insufficient critical mass in the centre to create results that are beyond the state of the art in this research area. We encourage the Centre to explore leveraging the complementary capacities of the broader SFI Manufacturing community in this area for example by addressing the cybersecurity of industrial systems and integrated metrology and sensing for automated inspection and quality assurance. Another area for further exploration is the collaboration between robots and humans given the involvement of the centre in relevant European projects. This would also be a common topic of interest with RA3. 2 PhD students, 1 Post Doc and 4 Masters students have been involved in the research activity in this area. Should further PhD students be recruited to this area it is strongly recommended that they focus on one of above recommended new topics and work more closely with industrial partners.

The focus of RA3 is on innovative and sustainable organisations and on understanding the behaviour of Norwegian industrial clusters. The work done so far appears to be valued by the industrial partners. The shift from survey based to scenario and case based methodologies is understood and

encouraged. From the work so far, this research area appears to have developed a critical mass of knowledge. This is reflected by the good collaboration with industrial partners as shown by the four spin-off projects and 10 Masters projects in cooperation with industry. The actors of RA3 are encouraged to create synergies with actors of RA2.

To improve technology transfer we encourage the Centre to produce technical reports together with industrial partners in addition to conventional academic publications.

Recommendation 1: The Centre should in particular leverage the problems and expertise of its industrial users to continue to shape its work in RA2 and better influence the supply of automation solutions that support the user partners to increase their competitiveness. This should consider links to other complementary world-leading Centres and capabilities in digitalisation.

Recommendation 2: The Centre should grow its activities in environmentally driven issues, for example those driven by material mixtures in both metals and polymers.

3 Internationalisation

International visibility and international collaborations have been mainly through participation in European funded projects, participation in international conferences, and involvement of some individuals within the centre in international communities such as CIRP and MANUFUTURE.

To enhance this, we encourage the Centre to develop direct international collaborations with identified, relevant, high-performing competence centres outside Norway and work with them on well-defined research topics. This should include collaborating in the recently initiated KIC in manufacturing. The evaluation team particularly consider that all of the Centre PhD students should have the opportunity for direct international cooperation with their peers outside Norway by laboratory secondment for example and that the Centre leadership actively encourages this.

The report of the recent International Scientific Advisory Board visit was currently confidential to the ISAB and Centre not available to the evaluation team.

Recommendation 3: The Centre should rapidly progress its work to define its international competitive edge. This process should be considered both from the perspective of Centre as a whole and of its individual components. Following this Centre should focus on areas of work with critical mass that are of clear benefit to the industrial partners and where the Centre has either international leadership or the potential for international leadership.

Recommendation 4: The Centre should grow more direct peer to peer links with other carefully identified similar international high performing centres both to encourage researcher mobility and increase its international differentiation.

4 Researcher training and engagement in education

There appears to be a gap with respect to training programs for PhD students with respect to relevant transferable skills including project management, intellectual property and communications skills. There are also gaps for many in their understanding of industry and the level of performance of their international scientific peers as discussed above. We strongly encourage industrial mentors to be involved in the supervision of PhD student projects and discussions on career development. PhD students should also spend some time in identified industrial partners relevant to their topic of research. PhD students should also be formally involved in the supervision of Masters student projects carried out in industry.

Recommendation 5: There is a requirement for cultural change to open the horizons of many of the research students and Post Docs. This has multiple components: training including for instance on project management and intellectual property; significantly increasing their closeness to industry, industry needs and industrial practice; and, in particular, international mobility to enable them to understand the level of performance of their peers in other nations.

5 Plans for final three-year period

The program proposed for balance of the Centre is appropriate given achievements so far and recognising that the Centre has a rolling one year planning horizon that allows some flexibility. We do however reiterate the comments above on the requirement to adjust the work in RA2 to ensure it is both more relevant to industrial partners' needs and timely and differentiated. It is anticipated that work going forward will focus on research at the intersection of the three research areas. The mix of researchers will also be more balanced between PhD students and Post Docs. It is thought that Post Docs will be more capable of doing the multidisciplinary work bridging the research areas while PhD students will within research areas. Recruitment of Post Docs should take this into account and the Centre should seek out Post Docs with international and/or industrial experience. More direct links between researchers and industry are necessary and this could be achieved with more and better involvement of PhD students in the definition and supervision of Masters projects to be performed in industry.

6 Organisation and Management of the Centre

The Centre has a clear identity and is visible nationally and internationally. The Centre board and management is high performing and well organised with many good well-established and effective processes. Discussions at the review however identified that communication could be improved within research streams and to give early warning of the dates of workshops and other whole Centre activities.

The Centre is an important component of the work of the host institution and the Centre Director is a member of its leadership team. The Centre has directly contributed to SINTEF Raufoss Manufacturing recognition as the full SINTEF institute SINTEF Manufacturing. The Centre has also contributed to catalysing and strengthening the regional cluster in manufacturing by providing a capability "umbrella" that industry can draw upon. There is good collaboration between the centre partners, but as has been commented upon elsewhere the PhD students could and should be closer to industrial partners.

7 Innovation and value creation

The Centre has 15 partners in different industrial high value manufacturing sectors including automotive/transport component suppliers, defence systems, and high value materials.

Impact on industry is mainly via the highly commendable associated projects. This is to our understanding the main knowledge transfer mechanism from the Centre RA1 and RA2 areas to the partners. For RA3 there is a good direct connection between research and some industrial needs/some partners. This way of organising knowledge transfer is reasonable and a good fit to the Centre business model, but there are more opportunities to secure knowledge transfer to the mutual advantage of all partners in the final period that should not be overlooked. These include:

- Identifying and integrating direct knowledge transfer to partners from each RA in parallel to the associated projects. This may mean that the centre should work somewhat further along the TRL-scale by doing proof of principle research, verification projects and demonstrators.
- More strategic use of MSc thesis projects to the benefit of all industrial partners. Set a clear goal for all RA for the final years of the Centre as matter of urgency with a minimum is at least one MSc thesis from each RA to an industrial partner if it matches the industrial partner needs. The board must secure this effort. This will also assist industry recruitment from the Centre by industry.
- Involving the PhDs to a larger extent in knowledge transfer from RA 1 and RA 2 to industry, including direct knowledge transfer. The industrial partners also need to be more closely involved with the PhDs and vice versa for example, as discussed elsewhere, by PhDs spending periods in industry. This also has the advantage of increasing their employability by making them more attractive to industry and increasing their understanding of future career pathways. See also recommendation 5.
- The evaluation team also expect that such actions would give rise to more joint publications between industry with the research staff in the centre.

Centre Management processes and reporting processes including the measurement of impact are clearly getting significant attention, however these actions also identify some further opportunities for improvement.

For example, if any patents or other intellectual property arise in an associated project originating from the results from the research in Centre, this is valid as a direct result from the Centre. However, there does not seem to be a routine in place to get access to this information today. In addition to this it is not clear how and when an associated project originating from explicit results from Centre feeds back into the work of the Centre and how the Centre keep tracks of the final transformation to industry in end of those projects.

The centre has commendably analysed the self-evaluation from industry. As discussed at the review, the self-evaluation documents give an impression that there is a wide range of opinion as to what extent industry has secured impact from the Centre and the interpretation of the value of the Centre diverges from industrial partner to industrial partner. The evaluation team emphasize that this must be addressed as a matter of urgency to secure meaningful impact on a majority of partners. The main responsibility to secure improvement is with the board.

The centre presented several associated projects and the innovation potential of the Centre in the paperwork and at the meeting tabled a report prepared by a consultancy. The evaluation team consider that this material could be presented in a more helpful way, for example by including improved clarity with respect to the detail 32 “innovation potential” items and the costs and risks to their deployment, and by being clearer about the extent to which the 30 associated projects originate from the Centre core research results. This impact on industry should also be presented on the Centre website in order to attract new partners and inform a broader audience of the power and value of the Centre.

The discussions above also indicate that the centre could more clearly identify KPIs that represent the overall impact on industry and its value to individual partners.

Recommendation 6: The Centre should better leverage Masters student projects, especially to ensure that each of the Centre partners gets benefit from its work.

8 Funding and financial aspects

The Centre has a good balance of cash and in kind from industry, which gives opportunities to act dynamically. The Centre also has some capacity to start smaller new projects. The Centre should consider increasing the budget for this to increase the dynamism of the centre provided the Centre board has full control of any additional budget allocation. Activities could include proof of principle research, feasibility studies and small demonstrators etc.

The number of funded associated projects is high commendable, huge in financial value, and extremely good for the final period of the Centre and beyond. As mentioned at the review the Centre would benefit by more clearly distinguishing the associated projects directly connected to research results arising from the Centre.

9 Gender aspects

The Centre has a good awareness of the equal opportunities issues in its domain, but should increase its efforts at the senior level. The current ISAB membership must be complemented with at least two women as a matter of urgency. The gender balance is good in the cohort of PhDs, Post Docs and Masters students.

Recommendation 7: At least two females should be included in the International Advisory Board.

10 Future activities

The Centre and SINTEF Manufacturing have successfully created a project generation engine capable of securing competitive funding that builds upon the core manufacturing science within the Centre. Currently much of this funding is national but the Centre is now targeting increasing its scale by seeking EU funding both as a project partner and a project leader. The Centre will necessarily have to ultimately regenerate its core manufacturing science and this is likely to require further RCN funding.

11 Conclusion and recommendations to the centre

This distributed, well-led and organised Centre has created a strong national community in manufacturing and is delivering results of real value to its partners. It has been particularly successful in creating spin-out projects. It has also demonstrably created capabilities within individual research partners that have significantly contributed to their development as organisations. There are however a number of opportunities for improvement presented in the recommendations below. Recurring themes that run through the recommendations are the requirements to drive in cultural change into the PhD student cohort and to carefully consider the direction of RA2 to ensure it has long term value to the industrial partners.

Recommendation 1: The Centre should in particular leverage the problems and expertise of its industrial users to continue to shape its work in RA2 and better influence the supply of automation solutions that support the user partners to increase their competitiveness. This should consider links to other complementary world-leading Centres and capabilities in digitalisation.

Recommendation 2: The Centre should grow its activities in environmentally driven issues, for example those driven by material mixtures in both metals and polymers.

Recommendation 3: The Centre should rapidly progress its work to define its international competitive edge. This process should be considered both from the perspective of Centre as a whole

and of its individual components. Following this Centre should focus on areas of work with critical mass that are of clear benefit to the industrial partners and where the Centre has either international leadership or the potential for international leadership.

Recommendation 4: The Centre should grow more direct peer to peer links with other carefully identified similar international high performing centres both to encourage researcher mobility and increase its international differentiation.

Recommendation 5: There is a requirement for cultural change to open the horizons of many of the research students and Post Docs. This has multiple components: training including for instance on project management and intellectual property; significantly increasing their closeness to industry, industry needs and industrial practice; and, in particular, international mobility to enable them to understand the level of performance of their peers in other nations.

Recommendation 6: The Centre should better leverage Masters student projects, especially to ensure that each of the Centre partners gets benefit from its work.

Recommendation 7: At least two females should be included in the International Advisory Board.

12 Recommendations to RCN

Comment to RCN: There is a concern about the culture of the PhD body and its unevenness. This may be a consequence of this Centre having an institute-based business model with a focus on the generation of associated projects and the decoupling of the knowledge generation step from the technology transfer step represented by the associated projects. It may also represent the large number of different departments and sites involved in both the Centre and the academic partner. A three year PhD model also constrains the amount of time available for training in transferable skills, and for industrial secondments and international placements. This is especially apparent in science and engineering. It is essential that the next generation of researchers are trained at an international level in the skills required for high quality and relevant research work at the industry interface. This may require 4 years of PhD funding.

David Williams (Chair)

Andreas Archenti

Dimitris Kiritsis

Mattias Lundberg

10 April 2019

CIRFA

Centre for Integrated Remote Sensing and Forecasting for Arctic Operations

1 Introduction

On 5 April 2019 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives, postdocs, PhD students, and representatives of the host institution, UiT, the Arctic University of Norway. In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

The Centre's work packages cover a broad range of scientific and technological expertise. WPs 1-3 have an excellent collection of scientific outputs with approximately 50 strong, peer-reviewed publications in world-leading journals. The research has also been presented at numerous international conferences and workshops with approximately 100 conference contributions. International contacts on different levels (e.g., visits, conferences, and joint projects and publications) are also commendable. The publication profile of WPs 4-6 is less strong, but this may be as expected given their focus on integration and knowledge transfer (see Section 6).

For WPs 1-3 the competence profile is excellent. It is commendable that a critical mass has been achieved for WPs 1-3 and there is a good mixture of experienced and young scientific leaders. For WPs 4-6, the competence profile is good, but the research questions are not clear. WP7 work started about one year ago and the strategy for this work package is general and lacks clarity. The Centre's scientific work includes results from scientists in three different fields: observation, modelling and remote sensing. Collaboration between these groups has been very good for specific cases. However, the general strategy for integration is not clear.

Recommendation 1: That the Centre establishes a proof of concept demonstrator including service provider and end user stakeholders and researchers from WP1, WP2, WP3 and WP6 to demonstrate the value of the research on ocean state, sea ice and oil spills to end users, e.g., through the development of automated, dynamic integrated products, such as automated high-resolution ice charts that take account of in-situ, near-real-time data and exploit algorithms developed within WP1, WP2 and WP3. Learning from such demonstrators is just one example of how user focused applications could be used to inform future research activities.

3 Internationalisation

The Centre's researchers participate in three EU projects and cooperate with many international research groups and 26 partner organisations. For such a short period of time, there is a high exchange of research personnel internationally. For example, the Centre employs three high profile foreign seniors, and eight outgoing and ten incoming visits by scientist have taken place. Opportunities for the PhDs are very good for research visits and attendance at international

conferences is encouraged. In addition, the Centre is involved in the delivery of an international summer school with colleagues from the USA and Canada.

4 Researcher training and engagement in education

The Centre has a strong cohort of PhDs and postdocs though few had clear plans for their future careers. All PhDs and postdocs have access to the host's researcher training programme. In the afternoon, the Director outlined a series of training events for the Centre's researchers, but these were one-off events rather than a coherent programme of opportunities for all researchers in the Centre. We encourage the Centre to consider such a programme. Topics could include career opportunities across the different value chains and sectors where the Centre's research could be exploited, IPR management, project management and leadership training.

5 Plans for final three-year period

In the final period it is essential that user needs are taken into account, e.g., when defining integrated sea ice products such as ice charts used in the navigation of ships. The plans to integrate the multiple sea ice products that have been developed have not been well described. For example, the use of multiple remote sensing instruments, such as microwave radiometers and microwave altimeters, in addition to SAR (Synthetic Aperture Radar) for improved sea ice parameter estimation is advisable.

Identifying new associated projects could guarantee the continuation of the work after the end of the funding period. In addition, developmental funding and additional investment from user partners will be necessary to deliver and support the fully operational services needed by end users.

Plans for WP7 are vague. WPs 1-6 are finalizing their ongoing work to support WP7. We expect that actions in response to Recommendation 1 will resolve this issue.

6 Organisation and Management of the Centre

The Centre includes a large volume of activities organised into seven work packages with a formal organisational structure in place. From the interview the evaluation team learned that excellent scientific results are being produced and shared with service provider partners. However, the formal organisational structure is not in use and it is not clear how integration across work packages is achieved.

The way in which the work package structure supports the vision of the Centre is unclear in that there are three science-focused WPs (1-3). For WPs 4-6, the competence profile is good, but the research questions are not clear and the overlaps in the work package structure do not reflect the integration needed to deliver the vision. For example, see Recommendation 1 which will require integration of activities in WPs 1, 2, 3, 5 and 7. Evidence for the scientific weakness of WPs 4-7 can be seen in the limited number of peer reviewed journal papers that they have produced to date. However, this may be because the research in WPs 4-7 is more applied and relevant to knowledge transfer. Evidence of this can be seen, e.g., in the number of associated and spin-out projects from WP4. WPs 1-3 are scientifically strong but, apart from ad hoc interactions between individual researchers, appear to be operating in silos. Increasing the integration (in terms of both the breadth of results and the tightness of integration) across these three work packages is likely to yield new scientific opportunities to the end of the funding period (e.g., through associated projects) and will

make the research results more accessible to more user partners in the Centre. We suggest that the Board ensures that this integration is implemented for the final three year period.

The visibility of the Centre is strong within the Centre and host but could be strengthened externally by ensuring that the web site is kept up to date and that all publications acknowledge the Centre funding. In addition, from the interview, the Centre has a much higher level of activity in associated projects than is reported. This should be reported fully to show the full capacity of the Centre and to facilitate the sustainment of the Centre after the eight year funding period.

The Board is well engaged and supported by the host institution. The Centre made a decision early in its life to appoint a Chair of the Board from the host institution. This may have been a good choice at that stage but, as the emphasis of the Centre's work transitions to be more focused on knowledge transfer, a Chair of the Board from a user partner may be better placed because they will be able to ensure directly that all partners benefit from belonging to the Centre.

The Scientific Advisory Board (SAB) has met annually by participating in each of the Centre's annual conferences. After each conference the SAB has a closed meeting with the Centre administration and work package leaders where oral feedback is provided and discussed. Although, after this meeting, SAB prepares a summary of its recommendations that is circulated to the Board, the feedback is provided on an informal basis directly to the Centre's management team and it is not clear that the Board is provided with opportunities to influence how the Centre responds to the feedback. We strongly advise that the SAB delivers an independent report to the Centre and that this is shared with the Board.

Recommendation 2: That the Centre reorganises how the Scientific Advisory Board reports to the Centre so that their feedback and suggestions for areas of improvement are reviewed by the Board.

Recommendation 3: That the Centre produces a map showing timescales for development of knowledge outcomes, e.g., based on a Technology Readiness Level model or in the form of a technology roadmap, and uses it to inform a revised and simpler organisational structure that is better suited to meeting the knowledge transfer needs of the Centre for the final three years. In this new structure, the roles and contributions of WPs 4-7 should be clear.

Recommendation 4: That the Centre operationalises the new structure, ensuring that all groups are active and meet as planned, the Chair of the Board is from a user partner, and the Centre discusses matters related to knowledge transfer, innovation and value such as IP.

Recommendation 5: That the Centre, for the final period and beyond, establishes a strategy for reporting associated and spin-out projects in a structured way, establishes a systematic way of recording knowledge outcomes (e.g., in technical reports), ensures all publications acknowledge the Centre, and maintains the web site to reflect the Centre's current status. In addition, this can be used to capture new topics and application areas for beyond the current funding period such as climate change and support of safety and rescue operations.

Recommendation 6: That the Centre Board ensures that, in the final period, all partners maximise the benefits they receive from belonging to the Centre.

7 Innovation and value creation

This Centre covers a value chain that ranges from fundamental research through to private and public sector service providers and end users. The range of user partners is appropriate but demands a more systematic and visible approach to knowledge transfer. There is some mobility of personnel

between research and user partners, but this could be increased. Unlike other Centres, the five papers co-authored with industry are listed as acknowledging industry rather than co-authorship. We suggest that the Centre improves this for the final period given the overall goals of the SFI scheme and the fact that the Centre will focus more on collaboration with user partners in the final period. The Centre does not use the formal mechanisms in the Centre agreement or from the research partners to report or monitor results with innovation potential. The Board should ensure that this issue is addressed in the final period.

8 Funding and financial aspects

The Centre has a balance of cash and in-kind contributions from partners that is appropriate but different to the norm for most centres. We expect that more in-kind support from user partners will be necessary as the Centre's work as knowledge transfer increases in the final three year period. The Centre already belongs to consortia in three EU projects which is commendable, and we hope that this level of EU funding is maintained, especially for after the SFI funding period.

9 Gender aspects

The gender balance is good at lower levels. At higher levels, the management group and Board are not gender balanced, but the SAB is. The host has good schemes in place to improve gender balance.

10 Future activities

At the time of the interview the Centre had no strategic plans for beyond the final three years. However, there are a significant number of associated projects from the Centre that are not clearly reported but suggest that the Centre has a promising long-term future. We suggest that the Board initiates discussions on this before the end of 2019. This could include identification of both new associated projects and new application areas. These discussions should be in close association with the user partners and SAB.

11 Conclusion and recommendations to the Centre

The Centre is carrying out world-leading scientific research that has resulted in outcomes that are of significant interest to the user partners. More systematic mechanisms are needed to ensure that all end users capitalise on the benefits from the knowledge that is being generated. This mid-term evaluation has highlighted areas which could be improved further and accordingly our recommendations to improve the Centre are as follows:

Recommendation 1: That the Centre establishes a proof of concept demonstrator including service provider and end user stakeholders and researchers from WP1, WP2, WP3 and WP6 to demonstrate the value of the research on ocean state, sea ice and oil spills to end users, e.g., through the development of automated, dynamic integrated products, such as automated high-resolution ice charts that take account of in-situ, near-real-time data and exploit algorithms developed within WP1, WP2 and WP3. Learning from such demonstrators is just one example of how user focused applications could be used to inform future research activities.

Recommendation 2: That the Centre reorganises how the Scientific Advisory Board reports to the Centre so that their feedback and suggestions for areas of improvement are reviewed by the Board.

Recommendation 3: That the Centre produces a map showing timescales for development of knowledge outcomes, e.g., based on a Technology Readiness Level model or in the form of a technology roadmap, and uses it to inform a revised and simpler organisational structure that is better suited to meeting the knowledge transfer needs of the Centre for the final three years. In this new structure, the roles and contributions of WPs 4-7 should be clear.

Recommendation 4: That the Centre operationalises the new structure, ensuring that all groups are active and meet as planned, the Chair of the Board is from a user partner, and the Centre discusses matters related to knowledge transfer, innovation and value such as IP.

Recommendation 5: That the Centre, for the final period and beyond, establishes a strategy for reporting associated and spin-out projects in a structured way, establishes a systematic way of recording knowledge outcomes (e.g., in technical reports), ensures all publications acknowledge the Centre, and maintains the web site to reflect the Centre's current status. In addition, this can be used to capture new topics and application areas for beyond the current funding period such as climate change and support of safety and rescue operations.

Recommendation 6: That the Centre Board ensures that, in the final period, all partners maximise the benefits they receive from belonging to the Centre.

Alison McKay (Chair)

Juha Karvonen

Mattias Lundberg

Thomas Pohlmann

1 May 2019

Smart Maritime

1 Introduction

On 9 April 2019 the evaluation team met with the Chair of the Board, the Director, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, SINTEF Ocean. In the morning the discussions focused on the research at the Centre and included a laboratory visit. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

It is noted that Moustafa Abdel-Maksoud was mentioned as a potential international research partner on the original Centre application, but this was not subsequently taken forward. This is therefore not a conflict of interest.

2 Research activities

The main objectives of SFI Smart Maritime are increasing ship energy efficiency and decreasing emissions. Both will have a great impact on improving the competitiveness of the Norwegian maritime industry.

The long-term industrial research is well described and current and expected international regulations regarding ship efficiency and emission limitations are taken into account. The interaction between academia, the research institute and industry are effectively organized and well balanced.

The technologies required to reduce the emissions and GHG will significantly influence the future of shipping. The most important research topics related to the SFI's objectives have been correctly identified and solutions developed within the framework of these research topics have the greatest potential to enable the achievement of these objectives.

The search for alternative fuel solutions to reduce ship emissions is a major task and many large research institutions and world leading ship engine manufacturers are actively engaged in it. The activities planned in the SFI can only be addressed by a strong team and in cooperation with machine manufacturers. The resource available in the SFI will not be sufficient to achieve significant progress if work is carried forward on a broad front. Therefore, it is important to define an important internationally differentiated niche research area and/or to significantly reduce the number of topics to be address. It is also important to strengthen international cooperation in this area.

This also applies to WP2. It is important to reduce the number of topics addressed in order to be able to go more deeply into those that are the most promising.

Key achievements of the Centre are the integration of findings at a vessel and fleet level within WP 4 and 5. In contrast to the recommendations above, the Centre is encouraged to maintain the wide scope in these WPs.

As digitization progresses, simulation methods are becoming more and more important. The work plan has great potential here. The enhancing and development of simulation-based methods and the integration of the numerical tools used by different disciplines within a user-friendly visualization framework is important. This will allow the investigation of ship performance and maritime structure

behaviour in different environmental conditions and operational situations. This approach is well recognised by the Centre; however, it is important that an appropriate compromise is found between solution accuracy requirements and practical computing constraints. Insufficiently accurate fast simulation results that require little computation time in the first design phase of the ship may lead to flawed decisions that are difficult or too expensive to correct in later design phases.

It is excellent that the simulation tool GYMIR in WP4 takes a wide scope of design considerations into account (including and building upon the results of WP 1-3) and integrates these into one simulation tool. Industry clearly states its high expectations for thus in the individual Partner assessments. It was however less clear how the economic and environmental tool MariTEAM (WP5) would ultimately interface with GYMIR. Will it directly feed into the simulation platform or will it be limited to making assessment calculations based upon the output from GYMIR?

The ship demonstrator cases that have been selected are very interesting and allow extensive interaction between the research team and the Centre industry partners. However, it is critical that these designs and the new technologies that they include are evaluated with respect to the performance required from the ships in the conditions expected in their target operating regions (wind, waves, current, ice, etc.).

The number of articles published is above average and the journals have a good ranking in the maritime community. Centre visibility could be increased by the organisation of international conferences and workshops in which tangible research results are presented in cooperation with the industrial partners. The focus of such presentations should be the innovations achieved and the new products developed based upon them. If these events were to be successful in attracting international attendees, their influence would also enrich SFI Smart Maritime.

The joint publications with industry representatives are commendable and will raise interest amongst experts and increase the recognition of the Centre by a broader industrial base. This is important to continue given that a main aim of the SFI programme is to encourage industry to be more engaged in long-term research.

Recommendation 1: Given the limited resources available to it the Centre should focus its work in Work Packages 2 and 3 by carefully considering the establishment of niches where it is internationally differentiated scientifically and can deliver distinct competitive advantage to the Smart Maritime partners.

Recommendation 2: The simulation framework and tools generated by Work Package 4 and its feeders represent a core deliverable from the Centre and are an important mechanism for the transfer of its outcomes to industry. It is essential that the limits on the applicability of individual tools and the uncertainties associated with their results are also understood and communicated to users. It is desirable that the simulation framework is open as this will allow that addition of further numerical and other tools.

3 Internationalisation

The majority of maritime transport is between countries and the industry is truly international with far-reaching division of labour between countries. Ongoing concentration in the shipping industry and in their supporting industries is also creating multi-national firms. Furthermore, regulation is getting stricter and has a geographically wider scope. Maritime research is therefore increasingly international and the significant challenges that face the industry tend to foster joint efforts in larger

collaborations. All the competencies required for the maritime industry moving forwards are not likely to be represented in Norway.

SFI Smart Maritime's internationalisation strategy primarily focuses on associated projects funded by the EU and particularly within Horizon 2020. SINTEF Ocean has significant experience of Horizon 2020 and has also secured considerable EU and other funding since starting the SFI Smart Maritime Centre. As demonstrated at the review a number of the associated projects are direct results of work in the Centre. The EUs framework programme is a good vehicle for international collaboration and efforts to secure funding from this should be kept at a high level, particularly to prepare for the life after SFI Smart Maritime.

NTNU's collaboration with non-Norwegian academic institutions, particularly in WP5, seems well thought through and has been guided by a strategic analysis. The participation in the writing of the next IPCC report is commendable and is likely to strengthen international collaborations.

The centre has identified a need for increasing international mobility and co-publication. There is some collaboration with non-Norwegian research groups, but this is primarily limited to other Scandinavian groups. A scientific article co-authored with members of the scientific advisory committee was mentioned to be in review, but further initiatives is encouraged. There are a few international recruits to the Centre, but both the senior staff and PhD students are primarily Norwegians. There is room for increased effort to recruit internationally. It would be also an advantage to extend the advisory scientific board with new members from non-European countries.

In discussion the PhD students stated that they felt that they had the opportunity to spend time abroad, but past personal experiences and stresses associated with finishing their theses made them hesitate. They should be encouraged to secure international experience beyond attending international conferences. There are several EU programmes to support the mobility of young scientists, which could be utilised to facilitate the mobility of FSI PhD students.

4 Researcher training and engagement in education

SFI Smart Maritime has a strong base from the work of its PhD students. They are largely engaged in the "technical" WPs (2-4). In addition to direct scientific support, the PhD students would value more support in planning their professional career. Many of them should also have closer direct links to industry, particularly those that do not yet have industrial experience.

The centre has involved 23 students writing MSc theses on work related to the centre. It is clear that the Centre has had a considerable impact on improving the qualification level of these master students. Many of these Master theses focused on improving the propulsion efficiency of ships and reducing fuel consumption. These topics are of high importance to the shipbuilding industry. Such graduates are highly employable by industry.

Although at the boundary of SFI Smart Maritime's scope, there seems to be room to involve more MSc students from NTNU's large Industrial Engineering programme. Such students might benefit the centre by, for instance, capturing how consumer pressure makes international supply chains change and how this is also translated to a need for change in the maritime industry.

Recommendation 3: PhD students must have closer direct contact with industry. This will ensure that they understand the reality of industrial problems and assist in the definition of the detail of their work to increase its applicability. It is preferable that these contacts are maintained through their PhD studies.

Recommendation 4: PhD students should have the opportunity to study outside Norway. Other Centres have shown the value of individual mentoring to assist PhD students to better understand their career options including the value of international experience.

5 Plans for final three-year period

The Centre has a clear strategy for the final three years that has been put together following their 2018 industry workshop, a review following the appointment of the new director at the close of 2018 and their preparation for the mid-term evaluation. The core of the strategy is to maintain their effort on the five work packages, to focus on the development and enhancement of the ship performance simulation platform and to drive forward three ship concept demonstrator cases. It is anticipated that one or more of the demonstration cases will ultimately be an associated project.

6 Organisation and Management of the Centre

The Centre has a strong identity but is aware that it needs to increase its visibility to relevant international research partners. The board appears well structured as presented, however it was difficult for the panel to assess the performance and engagement of the board given that only the Chair was only able to attend the meeting. The Centre confirmed the value of the RCN observer on the board. The Centre is well organised and technically co-ordinated. The Centre also has an industry co-ordinator at board level but has not yet really exploited this as an opportunity. Interaction with the host institution is good. It is clear that the Centre is important to the activities of the host and is influencing their long-term research strategy. Collaboration and participation of the research partners appears good.

7 Innovation and value creation

The 16 Centre industrial partners span most of the maritime sector value chain; 8 within design, equipment systems, 4 ship operators and 3 industry/public stakeholders. Most partners show that they are satisfied in the Centre self-evaluation report. All partners also have clear goals for what they would like the Centre to achieve on their behalf. However, there are partners that are still waiting for tangible knowledge transfer into their business. It is important that centre management have discussions with these partners to secure common expectations – industrial and scientific impact - for the final three years. We encourage the board focus Centre management on this.

The interaction between the partners and research activities is excellent. The Centre has good processes and good awareness of the alternative ways of knowledge transfer. In addition, the partners are well integrated into the process for steering changes to the Centre research activities, especially by the identification of business cases including the ship demonstrators and via the associated projects mechanism. The Centre should consider showing in a clearer way how business case projects and associated projects directly arise from the results of centre activities. The Centre must be able present the scale of its research power as its core activities and the associated projects explicitly derived from the core research results from the Centre.

However, the number of industrial partners that participated in the evaluation meeting was disappointing to the evaluation panel. Further there was only one member of the board that participated during the whole of the evaluation day. The evaluators do not require all partners to be present, but a minimum expectation is that representative members of the board are engaged in the review.

As already discussed, the number of Master theses in the Centre is good. However, the Board and partners should act in a more pro-active way to identify master topics to permit broader knowledge transfer to the benefit of all partners. Involvement of master students can also be used to incentivise the recruitment of the under-represented sex. This will also contribute to building a better long-term future for equal opportunity across the industry. It also gives an opportunity for all partners to get early access to either PhD candidates or candidates for recruitment.

We encourage the centre to plan for more co-authored publications with the partners in the final period of the Centre as also mentioned above. Importantly this has the benefit of acting as an excellent method for knowledge transfer.

We also consider that the board should act more pro-actively to secure explicit evidence of knowledge transfer to all partners.

The evaluation panel noted that some of the PhD students have extensive industrial experience, including with start-up companies. These are very important as role models for the other PhD and masters students. However, the interface of the PhD students with industry could be much improved as could their mobility. We encourage all partners to find ways to make contact with industry a natural part of the daily work of all PhDs. This will also act as an important tool for more two-way knowledge transfer. See recommendation 3 above.

Recommendation 5: The Centre should maintain its focus on ensuring that all partners take benefit from its work. Masters student projects are a good mechanism to permit this.

8 Funding and financial aspects

The core financial status of the centre is good and includes cash and in-kind contribution from partners. Both the strategy and outcome of securing associated projects from Norwegian and EU funding schemes is excellent.

9 Gender aspects

Awareness of equal opportunities issues is good in the Centre on multiple levels. However, the evaluation panel was particularly disappointed to see the missed opportunities, both short term and long term, to transform this awareness into clear actions.

We encourage the Centre to identify those opportunities/actions that need to be implemented as matter of urgency to change the poor statistics for the Centre. This should start immediately with the recruitment of master students with the identification of relevant and attractive topics for Master thesis and PhDs. There is also a need to encourage female students at all levels to be better connected to the industry, for example by a mentoring program with mentors from industry spanning the entire value chain. There is no doubt that this will assist in securing scientific and industrial impact and help the industry to be more competitive in the future.

The Centre has the opportunity to act as a long-term change agent. The Centre will be able to find both inspiration and proven best practice approaches, such as champions and mentoring, by discussions with other centres. It could also trigger social science (gender research) to establish ways of culture change for the industry as a whole. The centre should complement the existing ISAB with more female members as matter of urgency.

Recommendation 6: The Centre is aware that it needs to make more effort to address gender issues. As first steps the Centre must add female representation to its ISAB, focus on masters students, and should take professional advice on how to better address gender issues on behalf of the sector.

10 Future activities

The Centre is clear that it will continue to after the end of the current financing period because of its value to the partners and to the industry. The director shared a fee-based network to permit project generation as a candidate business model for continuation. The partners are also actively seeking funding from the SFI call using this Centre as a model. The Centre also has clear plans for the exploitation of its software tools.

11 Conclusion and recommendations to the centre

The Centre is performing well. Its vision is both timely and matches a long-term requirement. It is working to the benefit of the industry partners and the sector. It has refreshed leadership following a well-managed transition of director. It leverages strong physical and knowledge infrastructures.

Recommendation 1: Given the limited resources available to it the Centre should focus its work in Work Packages 2 and 3 by carefully considering the establishment of niches where it is internationally differentiated scientifically and can deliver distinct competitive advantage to the Smart Maritime partners.

Recommendation 2: The simulation framework and tools generated by Work Package 4 and its feeders represent a core deliverable from the Centre and are an important mechanism for the transfer of its outcomes to industry. It is essential that the limits on the applicability of individual tools and the uncertainties associated with their results are also understood and communicated to users. It is desirable that the simulation frame work is open as this will allow that addition of further numerical and other tools.

Recommendation 3: PhD students must have closer direct contact with industry. This will ensure that they understand the reality of industrial problems and assist in the definition of the detail of their work to increase its applicability. It is preferable that these contacts are maintained through their PhD studies.

Recommendation 4: PhD students should have the opportunity to study outside Norway. Other Centres have shown the value of individual mentoring to assist PhD students to better understand their career options including the value of international experience.

Recommendation 5: The Centre should maintain its focus on ensuring that all partners take benefit from its work. Masters student projects are a good mechanism to permit this.

Recommendation 6: The Centre is aware that it needs to make more effort to address gender issues. As first steps the Centre must add female representation to its ISAB, focus on masters students, and should take professional advice on how to better address gender issues on behalf of the sector.

12 Recommendations to RCN

Recommendation: RCN should identify domains / sectors with gender imbalance and invest in specific actions to initiate a change process with clear goals to accelerate change. Some SFI-Centres form role models for this in the Norwegian research and innovation landscape.

David Williams (Chair)

Moustafa Abdel-Maksoud

Mattias Lundberg

Johan Woxenius

29 April 2019

iCSI

- industrial Catalysis Science and Innovation for a competitive and sustainable process industry

1 Introduction

On 1 April 2019 the evaluation team met with the Chair and members of the Steering Board, the Director, partner representatives, postdocs, PhD students, and representatives of the host institution, Norwegian University of Science and Technology (NTNU). In the morning the discussions focused on the research at the Centre. In the afternoon there was a meeting with PhD students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and for the helpful discussions on the interview day.

2 Research activities

The Centre is focused on industrially relevant process-related questions. It is very positive that the industrial partners have selected research topics that span from very fundamental understanding to more applied points, with a good balance between challenging, high risk projects and lower risk ones. For instance, they are studying the Ostwald process, which is very well-established, but by tackling it with a more fundamental approach they have achieved a much deeper insight which has resulted in process improvements.

Overall, the research activities are at a very high level and competence and facilities are suitable to achieve the proposed goals. The development of toolboxes/methodologies to tackle the specific industrial questions is a sound approach to build a solid competence that can act as a seed to other projects/activities. The Centre has a sound critical mass and funding to achieve important results. The research program and goals are mostly suitable to reach the objectives, though some IIAs (Industrial Innovation Areas) should be more focused (see below). Based on the reports, not all the activities have been carried out uniformly.

The long term strategic funding is considered a very positive aspect of this SFI scheme and it is indeed the key to the achievement of successful results for complex research topics such as those being addressed within the Centre. For some IIAs this has led to a less focused strategy (e.g., IIA6 (Generic projects for additional industrial synergies)) which should be improved (see Sections 5 and 10).

Collaboration is active to acquire advanced instrumentation (e.g., a new generation of tapered element oscillating microbalance (TEOM)) by joint applications for funding with other research groups in Norway. This is a good way to create strong cooperation, which will lead to joint publications.

A high profile scientific advisory committee is positively engaged in annual meetings and they have given constructive remarks both to the senior researchers and to the Board, and advice on the general strategy. Furthermore, they have arranged 1:1 meetings with PhD students, which were judged very positively by the young researchers. The scientific outcome is testified by 17 scientific publications directly connected with Centre activities, plus 26 conference presentations and seven

invited lectures in circa 3½ years activity. This is a good level of productivity. Some papers appeared in good journals of the field, with some of them published in very high impact factor ones. The research profile and international visibility is good, with a high potential that the Centre can become an internationally established unit in the area of catalysis. The cross fertilisation and active engagement of companies is evident from the number of co-authored publications. An active involvement of the industrial partners is envisaged in the education and training mission of the Centre (see Section 4). The corporate partner assessment reports and comments during the interviews by some of the partners were very enthusiastic and reflect that the results to date, more or less, have met expectations. Some reports, however, were more critical and specific criticisms within these reports should be carefully taken into account and reflected in modified research and communication strategies. At the interview it was noted that this process had already started.

Recommendation 1: That the Centre, given the change of focus for IIA6, specifies clear goals for WP6 in the final three year period.

3 Internationalisation

The international level of the researchers of the Centre is recognised, as testified by the state-of-the-art level of some papers in very important journals and by some invitations for keynote lectures/invited speeches. Some (pre-existing) international collaborations add value and are testified by joint publications. The members of the Scientific Advisory Committee were selected from internationally recognised leaders of different topics and this improves the international character of the Centre.

Researchers of the Centre are involved in international projects (some funded by EU), though on topics not strictly related to the Centre. Some senior researchers have been involved in sabbatical leave abroad, while young researchers enrolled in the Centre have spent or plan to spend some time abroad at highly reputed research centres. The international mobility of PhD students and postdocs should be improved by increasing the length of time spent overseas in order to cross-fertilise effectively collaborations and improve the skills and networking experience of the young researchers themselves. The attraction of foreign senior researchers in the Centre is not reported and may be improved.

4 Researcher training and engagement in education

The researcher training programme is adequate for the formation of skilled researchers and the industrial partnership program adds value to the Centre. The meeting with the PhD students reflected their maturity and commitment to their research projects. They were aware of being part of the Centre and were enthusiastic about being engaged in such high level fundamental or applied research. Most of them have a clear view of their future plans, mostly as researchers outside academia. In addition, the PhD students and postdoc researchers working on associated projects were enthusiastic and supportive.

The PhD students are positive to cross work package discussions between each other on research issues, rather than only reporting success, and they are aware of the support of a solid scientific team. The number of Master students directly working on Centre projects was 22 and it is very positive that they were working together with the PhD students. This gives a mutual benefit, since the researchers can support the day-by-day activities in an effective manner while they learn how to manage collaborations and how to teach. We firmly believe that tutoring Master students is a good way to learn a subject area in depth.

The international mobility and the research exchange periods at the industrial partners is somehow limited for the young researchers and the Centre is advised to improve these periods in order to increase the training, which leads to increased employability of the PhD students. An important part of the success of a centre such as this, composed of a large group of young researchers, is the degree of social activities and this could be strengthened.

5 Plans for final three-year period

The Centre has clear plans for the final three years and these plans are supported by the industrial partners. However, several of the planned activities are very similar to those in the original proposal. These plans would be strengthened if they took account of the results achieved to date and of factors identified in the SWOT analysis. Overall, the plans for the final three years of the Centre would benefit from further development, including the identification of associated projects that could be funded from other sources.

Recommendation 2: That the Centre establishes a more proactive, ambitious and focussed strategy for the identification and development of the Centre including, e.g., associated projects during the final three year period and beyond the end of the funding period.

6 Organisation and Management of the Centre

The Centre is very well managed with a director who provides proactive and appropriate leadership. The Board is engaged with the research and enthusiastic. The organisation of the research into industrial innovation areas seems complicated but is appropriate in that it provides a framework for knowledge transfer across work packages and with industry. However, some concerns were raised by some industrial partners about communication with particular industry innovation areas. We suggest that the Board, in collaboration with the Centre management, use the partner reports to inform their response to Recommendation 3.

The visibility of the Centre is good but there are opportunities to improve communication with wider audiences, such as the public and policy makers. It was good to see that the Centre has practical plans to contribute to policy development, e.g., through the Norwegian Prosess 21 and European SPIRE initiatives. We encourage the Centre to further develop relationships in this area. The Centre's web site has an engaging front page but is incomplete in places. For example, some PhD students' web pages are incomplete. We strongly encourage the PhD students to maintain their own web page content, to which the Centre web site provides links, to share the enthusiasm for their research which was evident during the interviews. This can be a good medium for outreach and for further recruitment.

The host institution is strongly supportive of the Centre. However, there seemed to be some administrative tension between the Centre and host in arrangements for industry placements for students. We expect that the Board will address this issue for the final three years. Interactions between the Centre and the host are strengthened in a very good way by associated PhDs and postdocs who are funded from outside the Centre.

The three research and five user partners have distinctive but complementary areas of expertise that align well with the goals of the Centre. A particular strength is the combination of core scientific expertise from the universities and more applied research expertise from SINTEF.

Recommendation 3: That the Centre establishes a clear strategy for communication between academics and industrial partners. This needs to take into account the comments from industry partners in the mid-term evaluation report.

7 Innovation and value creation

The Centre has five very supportive industrial partners who constitute the majority of the catalysis industry in Norway and are very engaged with the research activities. All industrial partners are active members of the Board. From the self-evaluation reports and the interview, each of the industrial partners has a very clear view of how the Centre's research aligns with its business goals, and the new knowledge needed to improve both short and long term performance. For this reason, the industrial partners are supportive of research activities that enable incremental improvements in their manufacturing operations and those that are more focused towards scientific developments that could, in the longer term, lead to disruptive innovations. Over 50% of the total budget spent on research projects in IIA1-5 are with single industrial partners; this is significantly higher than the majority of other SFI centres. For the final three years we encourage the Centre to allocate more of the budget to multi-partner projects, either as IIA1-5 or in IIA-6.

The Centre delivers value to its partners both directly and indirectly. Individual projects are co-created with partners; this ensures that they align with industry needs. In addition, a particular strength is the cross-fertilisation across IIAs achieved directly or through generic projects in IIA6. We encourage the Centre to communicate this cross-fertilisation in a more engaging way because this could stimulate new associated projects and the recruitment of new partners and PhDs, during the final 3 years and beyond.

The industrial partners expressed their appreciation in the stability of the research activities that were carefully planned, in collaboration with them, at the beginning of the funding period. A drawback of this is that there are limited funds for flexibility to respond to unexpected research findings, new opportunities that arise and emerging industrial needs. We encourage the Centre to set aside funds for smaller feasibility studies in the final three years. These could also create opportunities for the development of associated projects for the final three years and beyond.

The majority of researchers have had industry placements and the industrial partners were positive about the employability of PhDs. Twelve journal papers co-authored with industry along with the development of patents provide strong evidence of highly effective collaboration and knowledge exchange with partners. For the final period, the evaluation panel encourages the Centre to provide opportunities for staff from the industrial partners to spend time in academia.

8 Funding and financial aspects

There is a good balance of cash and in-kind support from industry, which is matched by the research partners. The Centre operates in a highly competitive sector and it is therefore reasonable that they do not engage new industrial partners in the Centre for the final three years. External funding is relatively low (when compared with other centres) but we commend the Centre on its success in European programmes and encourage it to be more aggressive in finding associated projects, especially in new application areas, for the final three years and beyond. This is likely to lead to new partnerships that will contribute to the long term financial sustainability of the Centre.

9 Gender aspects

We commend the Centre on the gender balance at senior levels and their awareness of the situation regarding gender balance. We encourage the Centre to continue with their efforts to engage more female PhD students, especially given the gender balance of MSc students which, overall, is approximately 50% female, and was 60% in 2018.

10 Future activities

The plan for the possible continuation of the activities of the Centre is not very clear. Even if the formal calls and rules for future applications may not be available yet, it is important to define at least a general strategy for the follow-up of the competence and skills gained through this Centre.

It is not clear how the knowledge generated within the Centre will be valorised. For instance, IIA6 is one of the long lasting outcomes of the project and there is no clear plan to transfer it further into different projects or in the possible continuation of the Centre.

11 Conclusion and recommendations to the Centre

This is an excellent well-organised Centre carrying out internationally competitive research in response to industry needs identified with a committed group of industry partners. This mid-term evaluation has however highlighted areas which could be improved further and accordingly our recommendations to improve the Centre are as follows.

Recommendation 1: That the Centre, given the change of focus for IIA6, specifies clear goals for WP6 in the final three year period.

Recommendation 2: That the Centre establishes a more proactive, ambitious and focussed strategy for the identification and development of the Centre including, e.g., associated projects during the final three year period and beyond the end of the funding period.

Recommendation 3: That the Centre establishes a clear strategy for communication between academics and industrial partners. This needs to take into account the comments from industry partners in the mid-term evaluation report.

Alison McKay (Chair)

Mattias Lundberg

Lars Pettersson

Ilenia Rossetti

15 April 2019

MOVE – Marine Operations Centre

1 Introduction

On 11 April 2019 the evaluation team met with the Director, a board member, project leaders, industry representatives, postdocs, PhD students, and representatives of the host institution, NTNU. In the morning the discussions focused on the research at the Centre and included a visit to the simulation facilities associated with the Centre. In the afternoon there was a meeting with students as well as discussions on industry involvement, management, organisation and the future of the Centre. This evaluation is based on these interviews and on the written report and self-assessments supplied beforehand. We thank all members of the Centre for their efforts in providing information for the evaluation and the helpful discussions on the interview day.

2 Research activities

The Centre has outstanding research activities and shows the development of an excellent competence profile.

The number of academic members and PhDs / Post docs in the Centre shows that the overall activity is of good scale. However, the number of PhD students could perhaps be better balanced across the different sub-projects. The Centre should be careful to ensure, especially when the new projects start running, that each sub-project has critical mass. The composition of the partnership is well chosen with industrial partners covering the whole value chain. Specifically, the recruitment of new partners following the decline of certain business areas was a success.

The Centre is composed of excellent strategic research programmes which are well structured both as individual programmes and as a portfolio. The team, both the management and the board, was able to very successfully overcome a turndown in some areas of the industry by developing new business and research areas in response to the needs of the industry. Significantly, they also continued to support those PhD students who were working the original project areas to allow them finish their theses successfully.

During the review it became clear that the Centre has taken a long-term view to define important industry relevant research in the field as captured by the project descriptions. This follows the strategy of extending the research from design to operation (for example by the work with on-board decision tools and on dispersed operation). There are good plans for the final three years that are well-matched to industrial needs, for example floating assembly stations for Offshore Wind Turbines and dispersed ship operation.

Simulation is at the core of the research, the Open Simulation Platform therefore forms a very important base for the future of design and testing, training and operation of marine systems. An increased level of interaction and collaboration across the projects to leverage and further grow the capability in the modelling of systems (for example in workability and decision support for dispersed ashore and on-board crewing) would be of benefit to the Centre and add to the effectiveness of individual projects.

The merger of Ålesund University College into NTNU has assisted the former university college at the Aalesund campus to move to university level. However, it should be recognised that this has also created an asset for NTNU as a whole as it has allowed the addition of the operation of ships to existing capabilities in ship design such that the merged activity now covers the whole life cycle of

the ship / offshore structures. The strong practice-based and industry pulled approach at Ålesund also complements the perhaps more theoretical approach at Trondheim.

The Centre has generated a good number of scientific publications in high impact factor international journals (these include co-publications with user / industrial partners) and numerous papers have been presented at recognised international conferences. They demonstrate the successful research profile of the Centre and will give high international visibility to the Centre partners.

3 Internationalisation

The Centre has established international research co-operations including participation in one EU framework programme on training. However, they have been strategic in their approach to joining EU research projects by ensuring that potential projects add value to their industrial partners' businesses. We commend them on this measured approach and encourage them to continue it.

Collaborations exist with strong international research groups in Denmark, Japan and South Korea. It is recommended that the Centre expands its international partnerships with those who are working in similar areas. The Centre should particularly initiate a truly international scientific advisory group.

The research is attractive to foreign senior researchers, postdocs and PhD-students in the centre. Some students have also spent some time in international partners' institutions.

Recommendation 1: The Centre should consider carefully expanding complementary international research collaborations.

Recommendation 2: The Centre must constitute a gender balanced and truly international scientific advisory board with clear terms of reference including the requirement to prepare short written reports capturing its feedback.

4 Researcher training and engagement in education

There is an impressive engagement in education at Master's and PhD level, with high numbers of high quality of students. PhD students and Post Docs have also published a significant number of journal papers and have presented their research at international conferences. Some of the Centre's Early Career Researchers are clearly pioneering in key areas and are also promoting their excellent research internationally. The Centre researchers are highly motivated and committed and it is clear that the PhD students push for close links to industry.

The students are attracted by the international reputation of the partners, the first class infrastructure, and the good management of the Centre by the Director and academic and industrial supervisors. It is apparent that the centre of gravity of supervision is still in Trondheim, but this should be build up and transferred in a balanced way to Ålesund.

There is a good system for involving PhD students in the supervision of master student projects. Many of the PhD students participate in industrial activities both directly specific to their projects and more generally such as by site visits. They feel well supported by the Centre and the industrial partners.

5 Plans for final three-year period

The Centre has an exciting vision for the final period of its operation centred upon moving from work in the laboratory to demonstration of its technologies in sea-borne operations with partners. More

detailed plans confirm this vision and emphasise that the research strands forged during the direction change of the centre will be maintained. Research project plans progress from fundamentals towards key work areas more clearly focussed on problems of more immediate utility to industry partners including solution demonstration in real sea-borne situations.

6 Organisation and Management of the Centre

The centre has a clear identity and is visible within industry and locally. The centre partners are visible internationally. The centre clearly has excellent leadership and a good board. The centre is well-organised and management is high performing. Communication between the sites of the centre is good. The interaction with the host institution is good and the centre is important to the host especially given its impact on the growth of research excellence at the NTNU Campus in Ålesund and also within the local maritime industrial cluster. Participation and collaboration between research partners is excellent and there also is clear value for SINTEF Aalesund in the relationship.

7 Innovation and value creation

The Centre covers much of the entire value chain in maritime sector of Norway in an impressive way. We also note that SME's are connected to the Centre via the cluster organisation ÅKP/GCE Blue Maritime. The centre also has accepted the challenge of building new maritime industries in sub-sea mining and in deep-sea wind power. The formation of the Centre consortium with its carefully selected partners will ensure that the industry in the region stays world leading in its competitiveness. Significantly the Centre and ÅKP/GCE Blue Maritime are two of the creators of the Catapult DIGICAT, a cross industry test centre for virtual prototyping and digital twins, and originating from the maritime sector of Norway

The written material was not clear how knowledge transfer takes place to partners. However, the scale and impact of knowledge transfer to the partners was made clear in the presentation and discussion. The evaluation team think there are opportunities to improve both the visibility of knowledge transfer and its power by:

- Reporting the case projects as clear knowledge transfer to industry
- Reporting associated projects as below and including their value
 - Projects that started building on substantial results (knowledge transfer) and discussions within the centre;
 - Projects that started from discussions amongst centre partners (but without any direct, results based, knowledge transfer from the centre);
 - Projects that started outside the centre but that have potential (two-way) connection and knowledge transfer to the Centre and its partners.
- Engaging SMEs from the cluster initiative in closer connection to the Centres activities, for example, by identifying potential MSc thesis topics from SMEs (or from the Centre to SMEs). This could also grow potential connections between SMEs and the core partners by for example finding business-to-business opportunities.
- The number of Master theses from the Centre is very good. However, the Board and partners should act in a more pro-active way to identify topics in order to secure broad knowledge

transfer to all partners. Masters projects also form an opportunity for the partners to get early access to either PhD candidates or candidates for recruitment as employees.

- We encourage the centre to plan for more co-authored publications with the partners in the final period of the Centre. This is also an excellent way of facilitating knowledge transfer.

The partner reports in the self-evaluation show that most Centre partners are satisfied, but the marks for the question: "...has the centre influenced the R&D and innovation strategy of your company?" were low. All partners have clear goals for what they wish to achieve in the Centre. However, there are partners that are still waiting for tangible knowledge transfer into their business. It will be very important for the Centre management to have discussions with those partners to ensure that there are common expectations – industrial and scientific impact - for the final three years. The board should ensure that this effort takes place.

We encourage the industrial partners to further exploit opportunities for mutual mobility. This also acts as mechanism for knowledge transfer and gives access to potential recruits. It is important to recognise that in a cluster setting this assists in the personal development of individuals and the overall development of the cluster.

We also note that the centre has had success in recruiting new partners. This is particularly praiseworthy in the light of the recession in the industry.

Recommendation 3: The Centre should maintain its focus on ensuring that all partners take benefit from its work. Masters student projects are a good mechanism to permit this.

Recommendation 4: In its reporting the Centre must more clearly distinguish those associated projects and other initiatives directly arising from the work of centre.

8 Funding and financial aspects

The difficult transformation of the Centre due to the recession in the industry has been managed in a very commendable way. The way the Centre is setting a budget aside for new projects on an annual basis is also very good. The balance of cash and in kind contributions from partners also gives the Centre flexibility to dynamically respond to industrial needs. The Centre is encouraged to maintain its efforts in applying for associated projects. This is an important tool for the final period both to increase the power of Centre knowledge transfer and sustain the Centre activity beyond the eight-year period.

9 Gender aspects

The awareness of equal opportunities in the Centre is excellent on many levels even though its statistics in this area are poor at first sight. The Centre has opportunities, both short term and long term, to transform this awareness into clear actions.

We encourage the Centre to identify those opportunities/actions that need to be implemented as matter of urgency to accelerate change. These range from the recruitment of master students to the identification of appropriate attractive topics for Master thesis and PhDs. There is also a need to encourage female students on all levels to be connected to the industry. An excellent method for this the initiation of a mentoring program with mentors from industry across the whole value chain. This will definitely increase scientific and industrial impact and will enable the industry to be more competitive in the future. The Centre has the opportunity to act as a long-term change agent.

The Centre will find best practice ideas and inspiration in discussion with other centres. This could also involve social scientists (gender research) to establish ways of achieving culture change. As noted above when recruiting its new ISAB the centre should ensure gender balance in this group. We also challenge the industry to move from awareness to action to accelerate change, for instance by implementing an award for best equal opportunities company in the sector or region. This clearly needs resourcing. This could also include the cluster of SMEs.

Recommendation 5. The Centre has had some success in addressing its gender issues and should build on this by increasing its capability in this area with the target of increasing the rate of change in gender within the sector.

10 Future activities

The Centre and its Director are clear nucleators for important initiatives, some of which will no doubt permit some of its activities to continue. The evaluation panel encourage the leadership to maintain their momentum but ensure that they do not become too thinly spread.

11 Conclusion and recommendations to the centre

MOVE is an inspiring centre. It is delivering world class research that is of clear benefit and utility to its partners. It is well-managed and all partners are clearly engaged in its work. It forms a key component of the local internationally important maritime cluster and is acting as a nucleation point for other significant initiatives.

Recommendation 1: The Centre should consider carefully expanding complementary international research collaborations.

Recommendation 2: The Centre must constitute a gender balanced and truly international scientific advisory board with clear terms of reference including the requirement to prepare short written reports capturing its feedback.

Recommendation 3: The Centre should maintain its focus on ensuring that all partners take benefit from its work. Masters student projects are a good mechanism to permit this.

Recommendation 4: In its reporting the Centre must more clearly distinguish those associated projects and other initiatives directly arising from the work of centre.

Recommendation 5: The Centre has had some success in addressing its gender issues and should build on this by increasing its capability in this area with the target of increasing the rate of change in gender within the sector.

12 Recommendations to RCN

Recommendation: RCN should use high-performing centres and their best practices as role models for other centres. MOVE has notably demonstrated best practice in its management of the change of direction necessary consequent on changes in the business environment of its partners.

Recommendation: RCN should identify domains / sectors with gender imbalance and invest in specific actions to initiate a change process with clear goals to accelerate change. Some SFI-Centres form role models for this in the Norwegian research and innovation landscape.

David Williams (Chair)

Knud Benedict

Atilla Incecik

Mattias Lundberg

15 April 2019

Appendix

A. Terms of reference

B. Templates

C. List of Centres and Experts

The Research Council of Norway

Midway Evaluation of Centres for Research-based Innovation (SFI-III)

Background and Terms of Reference

1. Framework for the evaluation

1.1 Introduction

The main objective for the *Centres for Research-based Innovation (SFI)* is to enhance the capability of business and industry to innovate. The focus is on long-term research and close alliances between enterprises which are active in research, and prominent research groups.

The SFI scheme shall:

- Encourage enterprises to innovate by placing stronger emphasis on long-term research, and by making it attractive for enterprises that work on the international arena to establish R&D activities in Norway.
- Facilitate active alliances between innovative enterprises and prominent research groups.
- Promote the development of industrial research groups that are on the cutting edge of international research and are part of strong international networks.
- Stimulate researcher training in fields of importance to the business community, and encourage the transfer of research-based knowledge and technology.

The SFI scheme features a higher level of ambition, a longer term perspective and a more intense concentration of efforts than any of the Research Council of Norway's other innovation-related instruments. The SFI scheme specifically addresses the most research-active parts of Norwegian business and industry. The SFI scheme offers enterprises the opportunity to take a longer term perspective, ensure a continuum and reduce the risk associated with research initiatives. The SFI scheme may also promote quality and efficiency in the public sector.

For research-performing institutions, the SFI scheme offers opportunities for long-term competence development by engaging in research of a high international standard in close collaboration with industry.

The SFI scheme is administered by the Research Council of Norway and funded by the budgets of the Ministry of Education and Research (mainly) and the Ministry of Trade, Industry and Fisheries. Each of the centres may receive funding for maximum eight years; five years plus a final three year period provided a positive outcome of a midway evaluation.

1.2 Background for the evaluation

The midway evaluation is outlined in the document "SFI Requirements and guidelines". Under the auspices of the Research Council, roughly 3,5 years after the centres are established; there will be an evaluation of each centre. The evaluation will be based on a uniform scheme involving the Research Council's governing bodies.

The Research Council has formulated a number of success criteria for SFI (Appendix 1). A key questions for the evaluation shall be whether a particular centre is well underway to satisfy these success criteria. Particular emphasis shall be put on whether a centre is enhancing the capability of the non-academic partners to innovate.

Further, the evaluation is to assess the plans for the centre's activities in the potential final three-year period.

1.3 Purpose of the evaluation

The purpose of the evaluation is twofold. First, the evaluation will form the basis for a decision by the Research Council about whether to continue the individual centre for the remainder of the overall eight-year term, or to wind it up after five years. Second, the evaluation shall give advice on how to improve and further develop the centres.

1.4 The evaluation team

Each centre will be evaluated by a team of international experts:

- Two of the experts in the team will have the competence and the task to evaluate the centre mostly from a scientific point of view.
- Two persons in the team will have experience from similar programmes for university/research institute – industry research collaboration. These “generalists” will mostly look at the centre from the view of organisation, innovation and value creation.

The scientific experts will participate in the evaluation of one specific centre while the “generalists” will participate in the evaluation of several centres. Each centre may suggest up to five suitable scientific experts. The Research Council will decide whom to invite.

1.5 Organisation of the evaluation

The evaluation team will write and complete an evaluation report. The team itself decides on the distribution of work among its members. One of the "generalists" will typically lead the evaluation. The composition of the evaluation team will differ from centre to centre since the scientific experts are to evaluate a specific centre.

The background material for the evaluation will be distributed by The Research Council to all members of the evaluation team not later than one month prior to the evaluation. The evaluation of the 17 Centres will be carried out during the period February 2019 - April 2019.

The evaluation report is due within six weeks after the interview sessions.

The evaluation team will perform one day site visit to each centre. During the site visit the evaluation team should meet:

- The centre leader / centre director
- The chair of the centre board
- Representatives from the industrial and public partners
- Representatives from collaborating research institutions
- Host institution staff incl. representatives from the top management
- Research leaders active within the centre
- PhD students.

The Research Council staff will be present at the site visits. The staff will act as facilitators and should not take active part in the evaluation, but can add information during work sessions.

The meeting of the evaluation team with the parties from the centre will be divided into two main sessions, one session devoted to the research activities and one session devoted to organisation and innovation aspects. There will also be a separate session with the PhD students.

1.6 Basis for the evaluation assignment

The evaluation will review progress of scientific and industrial efforts, recognising it is early to expect conclusive results. The evaluators will form an opinion concerning the approach and

measures taken so far by individual centres to judge the potential for their long-term development towards a successful SFI. Evaluators may offer suggestions for remedial action to enhance the prospects for centre success. The success criteria for SFI (Appendix 1) are the main basis for the evaluation report.

1.7 Background material for the evaluation

The following written material will form the background for the evaluation:

- *Project description*
- *Budget tables from The Research Council project data base*
- *Annual reports 2015, 2016, 2017 and 2018 (draft) from the centres*
- *Work plan for 2019 including tables for funding and cost*
- *Report from the centre and its partners according to a standardised outline:*
 - A. A self-evaluation of the centre including sections on research accomplishments, important industrial or social results, progress towards realizing the centre's potential for innovation, internationalisation, recruitment, financial aspects and organisation.
 - B. Fact sheets including CV for the management team, data for the staff working in the Centre, lists of publications, PhD students, financial data and selected indicators.
 - C. An assessment of the centre from the host institution.
 - D. An assessment of the centre from each of the partners.
 - E. Present description/plan for final three-year period, including a plan for the winding up.
- *Report(s) from Scientific Advisory Committee (for centres which have established this)*
- *Documents describing the scheme (Research Council of Norway, June 2013):*
 - Centres for Research-based Innovation. Description of the SFI scheme.
 - Centres for Research-based Innovation. Requirements and guidelines.
 - The Centres for Research-based Innovation. Information to applicants.

2. Terms of Reference

The evaluation team will make the evaluation in the context of the success criteria for SFI (Appendix 1).

The scientific experts on the evaluation team will have the prime role in reviewing the scientific activities and achievements of the centre focusing on the following parts of the success criteria:

- Research activity
- Internationalisation
- Research training and recruitment

All the sub-points of the success criteria must be taken into account in the assessment.

The "generalists" on the evaluation team will have the prime role in reviewing organisation, innovation and value creation focusing on the following parts of the success criteria:

- Innovation and value creation
- Partners and funding
- Organisation.

All the sub-points of the success criteria must be taken into account in the assessment.

In a recent evaluation of the SFI scheme¹, it was pointed out that it was difficult to identify convincing results regarding the scheme's contribution to innovation and commercialisation. Therefore the evaluation team will comment specifically on how the centres are working towards

¹ Evaluation of the Scheme for Research-based Innovation (SFI). Report for the Research Council of Norway. DAMVAD Analytics. 31 January 2018.

achieving the scheme's main objective of enhancing the capability of business and industry to innovate.

The evaluation team will also comment on the present plans for activities for the centre's final three year period and plans for winding up.

Although the individual centres will be the main focus, the evaluators should also comment on the organisation of the SFI scheme and the role of the Research Council of Norway.

The evaluation reports will form the basis of a decision by the Executive Board of the Research Council of Norway concerning continuation or discontinuation of each centre. To avoid giving a premature indication of the Research Council's decisions, the Evaluation Committee is asked not to comment specifically on whether a centre shall be continued or not in the evaluation report.

Each evaluation report should be written in consensus by the evaluation team and delivered to the Research Council of Norway. The centres will be given an opportunity to comment the factual content of the report before it is finalised by the evaluation team. The final report will be openly circulated to all the centres, the host institutions, relevant ministries and to any other agency or person who have expressed interest for this kind of information.

Success criteria for the Centres for Research-based Innovation (SFI)

In addition to fulfilling the formal requirements, a successful Centre for Research-based Innovation will be characterised by the following:

Research activity

- The centre conducts long-term, business-sector relevant research of high international quality in the field specified in the project description, and demonstrates this through its production of doctorates, scientific publications, papers for presentation at recognised international conferences and other measures of scientific excellence.
- The centre has a distinct research profile and has been successful in achieving recognition at the international level (e.g. researchers associated with the centre have received awards or been invited to be keynote speakers at international conferences).
- Researchers from the host institution and partners participate actively in the centre's research.
- The centre's user partners have increased their research commitments both through participation in the centre's activities and their own R&D activities on topics of relevance to the centre.

Innovation and value creation

- The centre's research activity has generated or is expected to generate the potential for innovation and enhanced competitiveness among user partners and expectations about the ramifications for society over and above the partners' direct participation in the centre's activities.
- The centre has achieved reciprocal mobility of staff between the centre and user partners. Researchers from partners work at the centre, and research fellows and researchers from the host institution are seconded to the user partners for periods of time.
- The centre has implemented measures to ensure that the expertise and results achieved by the research activity are effectively transferred to and utilised by the partners.
- The centre paves the way for results that fall outside the user partners' core areas to be commercialised by other means, e.g. through establishing new research-based enterprises.

Internationalisation

- The centre is successful in international research cooperation, e.g. as a player under the EU's framework programme.
- The centre engages in active collaboration with international research groups and has contributed in other ways to the internationalisation of Norwegian research and business and industry.
- The centre attracts outstanding international researchers, including research fellows and senior staff, as visiting researchers.

Research training and recruitment

- The centre has an effective framework in place for researcher training, and helps to train highly skilled personnel in the centre's areas of specialisation.
- The centre is actively engaged in education, especially at the master's degree level, and promotes recruitment to the centre's subject areas with special focus on increased recruitment of women.

Partners and funding

- The centre receives long-term funding from the host institution and partners, and these have increased their funding to exceed the minimum requirements.
- Active efforts are made to attract new partners, and the centre's partners also include small and medium-sized companies with a high technology and innovation profile.
- The centre has been successful in securing other external funding.

Organisation

- The centre has a visible profile, a strong identity and a successful collaboration with its partners.
- The centre is organised in a manner that is well adapted to the host institution's organisation.
- The centre has a board and management which ensure that the intentions and plan for the centre are followed up.
- The centre has a common administration with a high degree of scientific and administrative autonomy.

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

A - The Centre Self-evaluation

.....
(Name of centre)

.....
(Project number)

<p>Deadline 14 December 2018</p>

To be prepared by the centre and signed by the Centre director and Chairman of the Board.

Maximum length 12 A4 pages (exclusive front page).

Word format, Times New Roman, 12 pitch font, single line spacing.

Guiding texts in the template can be deleted. All headings must be retained.

Background

This Self-evaluation should devote special attention to the items listed in “Success criteria for Centres for Research-based Innovation”. The main sections below are the same as in this document. In addition to the Self-evaluation for the centre each of the partners should submit a report.

Brief summary (approx. ½ page)

Progress of the centre, highlights, breakthroughs etc.

Write here....

1. Objectives

Primary and secondary objectives of the centre.

Write here....

2. Research (approx. 2 pages)

- *Research achievements*
- *Core competence of the research team*
- *Research facilities of the centre*
- *Comment on new types of collaboration since establishing the centre (within core group and between host institution and research/user partners)*
- *Comment on the centre wrt critical size*
- *Provide an overview of the research program*

Write here....

3. Innovation and relation to Centre user partners (approx. 3 pages)

For the centre as a whole describe:

- *What steps are taken to monitor innovation processes at the partners.*
- *The way key issues are identified by partners.*
- *Measures for establishing links and integration between research institutions and user partners and between the different user partners.*
- *The participation of user partners in research projects.*
- *Describe expectations of value of the centre for society at large over and above the partners' participation in the centre's activities.*
- *To what extent have the centre mutual mobility of personnel between the centre and the user partners.*
- *How has the centre ensured that the competence and results achieved by the research are effectively transferred to and utilised by the partners.*

- *Are efforts made to secure that results that user partners' are not interested to implement are commercialised by other means?*
- *Has the centre research generated additional concurrent R&D projects between research institutions and companies?*

Write here....

4. Internationalisation (approx. 1 page)

- *Describe how international research cooperation is attended including if the partners based on research projects in the centre have engaged in the EU's framework programme.*
- *Describe collaboration with international research groups and other ways of international collaboration both with academic researchers and industry.*
- *Describe international exchange of researchers, both centre staff going abroad and visiting foreign researchers, including post docs, research fellows and senior scientific staff from other institutions.*

Write here....

5. Recruitment (approx. 1 page)

- *Describe how the centre have organised researcher training at PhD level.*
- *Describe how the centre has engaged in education, especially at the master's level. Examples are researchers taking part in teaching, thesis of master students related to the research topics in the centre and summer jobs for students on projects in the centre.*
- *Describe specifically what has been done to improve the gender balance.*

Write here....

6. Funding (approx. 1 page)

- *Discuss concerns regarding financial matters. Note that numbers are to be submitted by RCN (budget tables).*
- *What have been done to attract new partners including small and medium-sized enterprises? (It is realised that some centres from the start have a rather complete set of partners, while others have a greater potential to attract additional partners.)*
- *Has the centre been able to obtain other external funding?*
- *Describe sources of non-centre funding supporting related research.*

Write here....

7. Organisation (approx. 2 pages)

- *Describe role and activities of the:*
 - o *Board*
 - o *Centre director*
 - o *Management team*
 - o *International Scientific Advisory Committee (if relevant)*
 - o *Other (if relevant)*
- *Comment on the scientific leadership of the centre.*
- *Describe the process of idea generation, project selection, project planning and project review.*
- *What steps are taken to stimulate innovation processes?*
- *Describe steps taken to stimulate mutual personnel mobility between user partners and research institutions.*
- *Describe status and role of the Centre in relation to different organisational levels of the host institution.*

Write here....

8. Communication (approx. 1 page)

- *Link to centre home page*
- *Communication activities*

Write here....

9. SWOT analysis

Based on the previous self-evaluation of the centre a SWOT analysis should be performed. This is considered to be a useful way to present the highlights of the status of the centre and may constitute a basis for the plans for the final three years of operation for the centre.

This SWOT analysis should include the following steps:

Describing internal factors:

The strengths and weaknesses of the organisation. These are related to organisation's resources (people, knowledge, financial means, and activities). The sources for this are the analyses mentioned above.

Describing external factors:

The opportunities and threats in the environment that have an effect on the organisation. These include changes in the policy domain, technological developments and economic factors. The analysis of the environment provides input for this.

Confronting internal factors (strengths, weaknesses) with external factors (opportunities, threats):

It is important to weigh the strengths, weaknesses, opportunities and threats by using a point system or a qualitative specification.

Developing ideas on strategic options:

Strategy development often occurs on the basis of a matrix in which the factors are presented in four cells based on strengths, weaknesses, opportunities and threats.

Example of SWOT table:

Strengths <ul style="list-style-type: none">• Advanced knowledge development;• The research is demand driven;• The partners are closely involved;• The activities have a clear effect;• A wide and active network, both nationally and internationally.	Opportunities <ul style="list-style-type: none">• Extra attention and resources from public agencies for innovation in the sector;• New technological breakthroughs in strategically important fields;• Opportunities of interaction with innovation programmes• Position to attract funding from EU framework programme
Weaknesses <ul style="list-style-type: none">• Transfer of knowledge not adequately addressed• Resources are not prioritised well• Number of partner companies too low	Threats <ul style="list-style-type: none">• The partner companies is under pressure by the economic crisis;• The end of centre funding will come before company partners are ready to implement results

Signatures

Place and date

.....

.....

Centre director
(Signature and name in print)

Chairman of the board
(Signature and name in print)

.....

.....

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

B - Fact sheet for the centre

.....
(Name of centre)

.....
(Project number)

<p>Deadline 14 December 2018</p>

*To be prepared by the centre and signed by the centre director.
Maximum length 6 A4 pages (exclusive front page).
Word format, Times New Roman, 12 pitch font, single line spacing.
Guiding texts in the template can be deleted. All headings must be retained.*

Contents

1. General information

The centre

Name of centre

Name of centre director (Short CV, Enclosure 1)

Management team (Short CVs, Enclosure 1)

Address

Host institution

Partners

(Indicate if the partner has joined the centre after the start or has left the centre)

- Research partner(s)
- Company partners
- Public partner(s)

Governance

Board members

Scientific Advisory Committee (if relevant)

Other (if relevant)

Additional comments to General information

2. Staff

- a. List senior staff members that spend more than 10 % of their time working in the centre in 2018 (name, affiliation, university degree, sex, position within own organisation, % of full time in centre).
- b. List Administrative and Technical staff (name, position)

Own hard and soft indicators

The centre is requested to come up with their own hard and soft indicators (quantitative and qualitative) in addition to the sub-items in 3-6. These should be the indicators that they find relevant to give a good documentation of the results of the centre.

3. Research

- a. The (up to) 20 most important publications (for the centre so far) that are a direct result of the work in the centre
- b. (Up to) 5 publications (for the centre so far) co-authored with user partners (industry and/or public partners)
- c. (Up to) 5 publications (for the centre so far) co-authored with international partners
- d. Complete lists of publications for the centre so far are listed in the Annual reports for 2015, 2016, 2017 and 2018 – or given in Enclosure 2.
- e. Any own research indicators.

4. Innovation

- a. List patent applications and patents (for the centre so far).
- b. Any own innovation indicators.

5. International cooperation

- a. List organisations in other countries that are taking active part in centre projects in 2018 (name of organisation, country, time period of project).
- b. List researchers in other countries that are taking active part in centre projects in 2018 (name, position, organisation, country, time period of project).
- c. List visiting senior researchers from other countries with a stay of more than two weeks in 2018 (name, position, organisation, country, duration of stay).
- d. List researchers from the centre with a visit of more than one month to other countries in 2018 (name, position, organisation, country, duration of stay).
- e. Any own indicators for international cooperation.

6. Recruitment

- a. List PhD students working in the centre in 2018, both those financed by the centre budget and those that work in the centre and receive funding from other sources (name, affiliation, source of funding, sex, nationality, period worked in the centre).
- b. List Post docs working in the centre in 2018, both those financed by the centre budget and those that work in the centre and receive funding from other sources (name, affiliation, source of funding, sex, nationality, period worked in the centre).
- c. List PhD thesis completed on projects in the centre so far (name, sex, title of thesis, adviser, institution granting degree).
- d. List M.Sc. thesis in centre in 2018 (name, title of thesis, sex, adviser, institution granting degree). A master student in the centre is writing his/her thesis on a topic within the research agenda of the centre and is supervised by one of the senior researchers in the centre.
- e. Any own indicators for recruitment.

Signatures

Place and date

.....

Centre director

(Signature and name in print)

.....

Enclosures

1. Selected CVs for the core team of the centre (max. 10 pages for the whole team)
2. Publications (only if not listed in the Annual reports)

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

C – Host institution assessment

**Please return the completed assessment directly to Marianne Nereng, The Research Council of Norway (mn@rcn.no) as an attachment to an E-mail
Deadline 14 December 2018**

.....
(Name of host institution)

.....
(Name of centre)

.....
(Project number)

To be prepared by the host institution and signed by the Project administrator.

Maximum length 4 A4 pages (exclusive front page).

Word format, Times New Roman, 12 pitch font, single line spacing.

Guiding texts in the template can be deleted. All headings must be retained.

Contents

1. *What is the total research activity of the host institution in the form of personnel and volume within broad thematic area of the centre?*

Write here....

2. *Describe how the thematic area of the centre relates to the research strategy of the host institution.*

Write here....

3. *How do you evaluate the importance of the centre to realise the research strategy of your institution?*

Write here....

4. *How has the centre stimulated collaboration between researchers from different disciplines internally within the host institution and with researchers from research partners?*

Write here....

5. *How has the centre stimulated establishing leading national research groups across institutional borders, i.e. collaboration between university and research institute?*

Write here....

6. *How has the centre's activities benefited your international reputation as a research institution?*

Write here....

7. *How has the centre strengthened international cooperation?*

Write here....

8. *What potential for innovation and value creation do you see in the results from the centre which is not expected to be commercialised by the company partners?*

Write here....

9. *How is the centre organised within your own organisation?*

Write here....

10. *How are the administrative and economic matters handled?*

Write here....

11. *Are there any other topics you want to report?*

Write here....

Host institution

.....

Place and date

.....

Signature and name in print of project administrator

.....

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

D1 – Corporate partner assessment

.....
(Name of partner)

**Please return the completed assessment directly to Marianne Nereng, The Research Council of Norway (mn@rcn.no) as an attachment to an E-mail
Deadline 14 December 2018**

.....
(Name of centre)

.....
(Project number)

*To be prepared by the partner and signed by the contact person of the partner.
Maximum length 3 A4 pages (exclusive front page).
Word format, Times New Roman, 12 pitch font, single line spacing.*

Outline

1. Describe the focus of your company's own R&D in the thematic area of the centre, within and outside the centre (strategic platform).

Write here....

2. What is the total volume of R&D of your company within the thematic area of the centre (man-years, number of employees or annual budget).

Write here....

3. How has the participation in the centre influenced the R&D activity of your company?

Write here....

4. How has your company as a partner interacted with the centre?

	Yes	No
Membership in board		
Participation in workshops for project plans and idea generation		
Participation in research projects in the centre		
Mechanisms for technology transfer		
Mobility of personnel		
Other (specify)		

If further comments, write here.....

5. What opportunities have been created that would not have existed without the centre?

Write here....

6. Has the centre contributed to specific innovations within your company?

	Yes	No
Patents		
New or improved products		
New or improved processes		
New or improved services		
Other (specify)		
Other (specify)		

If further comments, write here.....

7. *Can you give any estimate of potential for increased income or reduced cost in net present value as a result of being a partner in the centre? If estimates and numbers cannot be given, please describe in words what your company gains from being a partner in the centre.*

Write here....

8. *On a scale from 1 (Low) to 6 (High), please give your score for each of the following questions:*

	Score
A. Has the participation in the centre influenced the R&D and Innovation strategy of your company?	
B. How do you evaluate the centre wrt:	-----
Level of competency of centre staff	
Project management of centre	
Communication between centre and partners	
The usefulness of research activities as seen from the company	
C. How has the centre's activities benefited the partner wrt:	-----
Ideas for new products, processes and/or services?	
New or improved methods/models developed by the centre	
Improvement of products, processes and/or services	
Strengthened knowledge base of the company	
Improved access to competent personnel and knowledge institutions	
Recruitment of qualified personnel	
Improved network to other partners	
Increased competitiveness within the area of research of the centre	

If further comments, write here.....

Company partner

.....

Place and date

.....

Signature and name in print of reporting person from partner

.....

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

D2 – Research partner assessment

.....
(Name of partner)

**Please return the completed assessment directly to Marianne Nereng, The Research Council of Norway (mn@rcn.no) as an attachment to an E-mail
Deadline 14 December 2018**

.....
(Name of centre)

.....
(Project number)

*To be prepared by the research partner.
Maximum length 3 A4 pages (exclusive front page).
Word format, Times New Roman, 12 pitch font, single line spacing.*

Contents

1. *What is the total research activity of your institution in the form of personnel and volume within the (broad) thematic area of the centre?*

Write here....

2. *Describe how the thematic area of the centre relates to the research strategy of the your institution*

Write here....

3. *How do you evaluate the importance of the centre to realise the research strategy of your institution?*

Write here....

4. *How has the centre stimulated collaboration between researchers from your institution and from the host institution and other partners?*

Write here....

5. *How has the centre stimulated establishing leading national research groups across institutional borders, i.e. collaboration university and research institute?*

Write here....

6. *How has the centre's activities benefited your international reputation as a research institution?*

Write here....

7. *How has the centre strengthened international cooperation?*

Write here....

8. *What potential for innovation and value creation do you see in the results from the centre which is not expected to be commercialised by the company partners?*

Write here....

9. *Has the centre contributed to investment in research infrastructure?*

Write here....

10. *Has the centre contributed to improvement in study programmes at Master level (only relevant for universities)?*

Write here....

11. *Has the centre contributed to improvement in doctoral education (only relevant for universities)?*

Write here....

12. *Are there any other topics you want to report?*

Write here....

Name of Research partner

.....

Place and date

.....

Signature and name in print of contact person

.....

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

D3 – Public partner assessment

**Please return the completed assessment directly to Marianne Nereng, The Research Council of Norway (mn@rcn.no) as an attachment to an E-mail
Deadline 14 December 2018**

.....
(Name of partner)

.....
(Name of centre)

.....
(Project number)

*To be prepared by the partner and signed by the contact person.
Maximum length 3 A4 pages (exclusive front page).
Word format, Times New Roman, 12 pitch font, single line spacing*

Outline

1. Describe the focus of your organisation's own R&D in the thematic area of the centre, within and outside the centre (strategic platform).

Write here....

2. What is the total volume of R&D of your organisation within the thematic area of the centre (man-years, number of employees or annual budget)?

Write here....

3. How has the participation in the centre influenced the R&D activity of your organisation?

Write here....

4. How has your organisation as a partner interacted with the centre?

	Yes	No
Membership in board		
Participation in workshops for project plans and idea generation		
Participation in research projects in the centre		
Mechanisms for technology transfer		
Mobility of personnel		
Other (specify)		

If further comments, write here.....

5. What opportunities have been created that would not have existed without the centre?

Write here....

6. Has the centre contributed to specific innovations within your organisation?

	Yes	No
New or improved services		
Other (specify) ...		
Other (specify) ...		

If further comments, write here.....

7. *Can you give any estimate of potential for increased income or reduced cost in net present value as a result of being a partner in the centre? If estimates and numbers cannot be given, please describe in words what your institution gains from being a partner in the centre.*

Write here....

8. *On a scale from 1 (Low) to 6 (High), please give your score for each of the following questions:*

	Score
A. Has the participation in the centre influenced the R&D and Innovation strategy of your organisation?	
B. How do you evaluate the centre wrt:	-----
Level of competency of centre staff	
Project management of centre	
Communication between centre and partners	
The usefulness of research activities as seen from the organisation	
C. How has the centre's activities benefited the partner wrt:	-----
Ideas for new products, processes and/or services?	
New or improved methods/models developed by the centre	
Improvement of products, processes and/or services	
Strengthened knowledge base of the organisation	
Improved access to competent personnel and knowledge institutions	
Recruitment of qualified personnel	
Improved network to other partners	
Increased competitiveness within the area of research of the centre (if relevant)	

If further comments, write here.....

Name of public partner

.....

Place and date

.....

Signature and name in print of reporting person from partner

.....

The Research Council of Norway

Midway Evaluation of the Centres for Research-based Innovation (SFI)

E – Project description for the final three-year period and further plans

.....
(Name of centre)

.....
(Project number)

<p>Deadline 14 December 2018</p>

*To be prepared by the centre and signed by the Centre director and Chairman of the Board.
Maximum length 8 A4 pages (exclusive front page).
Word format, Times New Roman, 12 pitch font, single line spacing.
Guiding texts in the template can be deleted. All headings must be retained.*

Background

Each centre has a current project description for the whole period of the centre and a work plan for each year. During the four to five years since the original project description was written, several things may have changed. Even if some centres have made revisions through the first years, it is expected that the centre now should perform a more in depth review of the different sections of the project description. ***This report should focus topics that, as a result of this review, is going to be changed in the project plans for the final years. Those items where the centre will continue to follow present plans need not be commented upon.***

The centres may not have budget plans for the complete eight year period. In any case the budget for the next four years should be presented.

Objectives for the centre and background for changes in the project description

Write here....

1. Status

National and international state-of-the-art of the relevant technologies and research topics for the centre.

Write here....

2. Research methodology

Describe the methodology and theories planned used, and explain why they are suitable for generating relevant knowledge in the field and promoting future value creation. Describe plans for publication in scientific peer-reviewed journals as well as plans for conferences and any patents.

Write here....

3. Research tasks

Identify and describe the research questions that will be examined. Define key research tasks and research-related targets and explain their significance for future innovation and value creation.

Write here....

4. Researcher training and recruitment

Describe plans for researcher recruitment. Specify the number of doctoral degrees planned within which research areas. Provide a target figure for the percentage of women fellowship-holders.

Write here....

5. Significance for the business sector

Describe how the knowledge developed by the centre will be important to future innovation and value creation for the user partners. Describe the potential that the centre's results may have for generating innovation and value creation in other segments of the Norwegian business sector. Describe the centre's relevance and benefit to society.

Write here....

6. Organisation

Describe how the cooperation at the centre will be organised and why this structure has been chosen. Describe how knowledge acquired through research activities at the centre will be transferred to the individual partners to stimulate innovation and value creation.

Write here....

7. International cooperation

Describe plans for international cooperation at the centre.

Write here....

8. Gender balance

Describe how gender-related considerations will be incorporated into the centre's activities and describe specifically what will be done to improve the gender balance (if still needed).

Write here....

9. Progress plan with milestones

The plan should provide a timeline for and describe the main activities and milestones, including project deliveries associated with the given milestones.

Write here....

10. Budget

General comments on budget situation. Action plans for the final three year period.

Write here....

11. Costs distributed among the individual partners

An overview of how the project costs will be distributed among each of the R&D-performing partners is to be presented in table form.

Cost	2019	2020	2021	2022	2023
Host institution					
Consortium partner A					
Consortium partner B					
Consortium partner C					
Consortium partner N					
Total					

12. Financial contributions from the individual partners

An overview of the partners that will contribute financing to the centre and their individual contributions are to be presented in table form.

Funding	2019	2020	2021	2022	2023
RCN SFI-grant					
Host institution					
Consortium partner A					
Consortium partner B					
Consortium partner C					
Consortium partner N					
Other public funding					
Total					

13. Environmental impacts

Describe whether and how the research conducted by the centre or the use of the results will have environmental impacts of significance (positive or negative).

Write here...

14. Plans for further activities after the eight year period of financing from RCN

Describe plans for further activities after the funding from the Research Council ceases. Describe how results and values created by the centre will be preserved or continued, including any infrastructure established under the auspices of the centre.

Write here....

Signatures

Place and date

.....

.....

Centre director
(Signature and name in print)

Chairman of the board
(Signature and name in print)

.....

.....

List of centres and experts

237718

BIG INSIGHT – Statistics for the knowledge economy

Host institution: Norwegian Computing Center

Professor Mary O'Kane, O'Kane Associates, Australia (generalist - panel leader)

Professor Alison McKay, University of Leeds, UK (generalist)

Professor Juni Palmgren, Karolinska Institutet (KI), Sweden (scientific expert)

Professor Anthony C. Davison, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland (scientific expert)

237738

Metal Production

Host institution: NTNU

Professor Mary O'Kane, O'Kane Associates, Australia (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Manager Isabel Geldenhuys, Mintek, South Africa (scientific expert)

Professor Bart Blanpain, KU Leuven, Belgium (scientific expert)

237766

C3 – Centre for Connected Care

Host institution: Oslo University Hospital

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Professor Mary O'Kane, O'Kane Associates, Australia (generalist)

Professor Inger Ekman, University of Gothenburg, Sweden (scientific expert)

Professor James Barlow, Imperial College Business School, UK (scientific expert)

237790

EXPOSED – Exposed Aquaculture Operations

Host institution: SINTEF Ocean AS

Professor Mary O'Kane, O'Kane Associates, Australia (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Senior Manager Robin Shields, Scottish Aquaculture Innovation Centre, UK (scientific expert)

Professor Erik Damgaard Christensen, Technical University of Denmark, Denmark (scientific expert)

237841

FOODS – Foods of Norway

Host institution: Norwegian University of Life Sciences (NMBU)

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Kristiina Kruus, VTT Technical Research Centre, Finland (scientific expert)

Professor John O'Doherty, University College Dublin, Ireland (scientific expert)

237856

CtrlAQUA – Centre for Closed-containment Aquaculture

Host institution: Nofima AS

Professor Mary O'Kane, O'Kane Associates, Australia (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Felicity Huntingford, University of Glasgow, UK (scientific expert)

Professor Uwe Waller, University of Applied Sciences in Saarbrücken (htw saar), Germany (scientific expert)

237859

Klima 2050 | Risk reduction through climate adaptation of buildings and infrastructure

Host institution: SINTEF AS

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Carsten Rode, Technical University of Denmark, Denmark (scientific expert)

Professor Marina Bergen Jensen, University of Copenhagen, Denmark (scientific expert)

237885

CASA – Centre for Advanced Structural Analysis

Host institution: NTNU

Professor Mary O'Kane, O'Kane Associates, Australia (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Eric Markiewicz, University of Valenciennes, France (scientific expert)

Professor Mats Oldenburg, Luleå University of Technology, Sweden (scientific expert)

237887

CIUS - Center for innovative ultrasound solutions for health care, maritime, and oil & gas industries

Host institution: NTNU

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Prof. Dr. Mario Kupnik, Technische Universität Darmstadt, Germany (scientific expert)

Professor Nico de Jong, Erasmus Medical Center, The Netherlands (scientific expert)

237893

SUBPRO - Subsea production and processing

Host institution: NTNU

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Hervé Carrier, University of Pau (UPPA), France (scientific expert)

Professor Krzysztof Wolski, Mines Saint-Etienne, France (scientific expert)

237896

Center for Offshore Mechatronics

Host institution: University of Agder

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Professor Mary O'Kane, O'Kane Associates, Australia (generalist)

Professor Neil Duffie, University of Wisconsin-Madison, USA (scientific expert)

Professor Anders Robertsson, Lund University, Sweden (scientific expert)

237898

SIRIUS - Centre for Scalable Data Access

Host institution: University of Oslo

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Tiziana Margaria, University of Limerick, Ireland (scientific expert)

Dr. Edward Curry, The Insight Centre for Data Analytics, Ireland (scientific expert)

237900

Manufacturing - Sustainable Innovations for Automated Manufacturing of Multi-Material Products

Host institution: SINTEF Manufacturing AS

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Andreas Archenti, KTH Royal Institute of Technology, Sweden (scientific expert)

Professor Dimitris Kiritsis, École Polytechnique Fédérale de Lausanne (EPFL), Switzerland (scientific expert)

237906

CIRFA - Centre for Integrated Remote Sensing and Forecasting for Arctic Operations

Host institution: UiT – The Arctic University of Norway

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Dr. Juha Karvonen, Finnish Meteorological Institute, Finland (scientific expert)

Dr. Thomas Pohlmann, Universität Hamburg, Germany (scientific expert)

237917

Smart Maritime - Norwegian Centre for improved energy efficiency and reduced emissions from the maritime sector

Host institution: SINTEF Ocean AS

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Johan Woxenius, University of Gothenburg, Sweden (scientific expert)

Professor Moustafa Abdel-Maksoud, Hamburg University of Technology (TUHH), Germany (scientific expert)

237922

iCSI - industrial Catalysis Science and Innovation for a competitive and sustainable process industry

Host institution: NTNU

Professor Alison McKay, University of Leeds, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Ilenia Rossetti, University of Milano, Italy (scientific expert)

Professor Lars Pettersson, KTH Royal Institute of Technology, Sweden (scientific expert)

237929

MOVE – Marine Operations Centre

Host institution: NTNU

Professor David Williams, Loughborough University, UK (generalist - panel leader)

Dr. Mattias Lundberg, Swedish Foundation for Strategic Research, Sweden (generalist)

Professor Knud Benedict, Hochschule Wismar, Germany (scientific expert)

Professor Atilla Incecik, University of Strathclyde, Glasgow, UK (scientific expert)



The Research Council of Norway
Drammensveien 288
P.O. Box 564
NO–1327 Lysaker

Telephone: +47 22 03 70 00
post@rcn.no
www.rcn.no

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