The Research Council of Norway

Research in Information and Communication Technology in Norway

An evaluation

Evaluation
Division for Science

The Research Council of Norway

Research in Information and Communication Technology at Norwegian Universities, University Colleges and Selected Research Institutes

An evaluation, February 2012

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To the Research Council of Norway

The members of the Evaluation Committee for Research in Information and Communication Technology at Norwegian Universities, University Colleges and selected Research Institutes hereby respectfully submit the following report. The views presented in this report are expressed in consensus among the members of the committee and the committee is in collective agreement with the assessments, recommendations and conclusions presented.

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The CV's of the international evaluation committee members are included in Appendix B.

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1. Executive Summary

Information and communication technology (ICT) continues to increase its penetration into all sectors of a modern nation. The importance of preparing and training its citizenry in the secure and informed use of this continues to expand in importance as ICT becomes woven into all essential aspects of a modern digital society.

This report seeks to provide a perspective on the health of ICT research across Norwegian universities, university colleges, and selected research institutes and to offer recommendations on how the current expertise and investment can be harnessed to secure Norway an international leadership role in ICT, commensurate with its advanced standing by other international measures.

The report is based on the views and impressions of an eight-member international committee of academic peers that interviewed many of the principals of Norwegian ICT during a weeklong meeting in October 2011 in Oslo. These interviews were complemented by advance surveys and self-studies of all reviewed institutions. This report seeks to integrate and present the findings, conclusions, and recommendations following this process.

In line with past reports, one of the major findings of the committee is that Norway continues to *lack a national strategy for ICT* and generally *underinvests* in ICT relative to its importance and potential and when compared to many of its peers in Western Europe and North America. This long held policy increasingly poses threats to the ability of Norway to educate its citizens and position itself to take full advantage of the societal transformation enabled by ICT. Furthermore, what the panel perceives as an insufficient national research focus in such areas as cyber security poses potential real threats to the security of Norway.

A central finding is that the country possesses international strengths in a number of areas beyond what could be expected from its relatively small investments. One cannot realistically expect that Norway hold international leadership in all areas required in a healthy ICT-driven economy. However, it is the belief of the evaluation committee that Norway has a substantial potential to provide leadership to an extent beyond what it is currently doing, to retain more of the human capital it helps to develop through its generous educational system, to mentor and mature its rising generation of researchers, and to enjoy increased future economic benefits by building on strengths and by coordinating and increasing the share of national research resources dedicated to the ICT arena.

A similar national assessment was last conducted in 2002, at a time where there were clear indications of the pervasive importance of ICT to the nation. The evaluation in 2002 made a number of strong recommendations, some posed with a certain sense of urgency. While the current committee acknowledges that major advances have been made during the last decade, it shares the disappointment with the previous committee to see that some of its findings in 2012 echo those of previous committees.

We note:

- A relatively low level of support for basic research in ICT, both in terms of general resources and through support for advanced equipment and its maintenance.

- Distribution of funds is primarily tied to students with few alternatives.

- A lack of a national strategic organization for ICT research and PhD education and mentoring of young researchers, leading to inefficient allocation and use of Norway's most valuable asset – its people.

The following concrete recommendations aim to address these concerns and to help position Norway to exercise international scientific leadership in current and future vital areas of ICT:

- Develop a national ICT research strategy that focuses on technical excellence, that balances established and emerging areas, and that considers the peculiarities of the Norwegian industry and society besides the global international context.

- University departments and research institutes in ICT should be encouraged to compare their research focus, vision, and productivity annually with a set of leading peer organizations outside of Norway.

- Develop or strengthen an innovation strategy and the supporting incentives – also within universities and research institutes - towards the economic valorization of ICT research results, encouraging entrepreneurship and fostering transfer of knowledge to existing or new (startup) companies, thus helping in the creation of high-value jobs in ICT.

- ICT organizations should seek to better coordinate their educational offerings, flow of personnel, construction and support of facilities and advanced research infrastructure. For a small country like Norway, this has to be a balance between fostering healthy competition and achieving efficiencies of scale.

- Increase national coordination of PhD education to ensure uniform quality and increase mobility, and to help establish networks among young researchers.

- Enhance awareness of the critical importance of mentoring and training of junior post-PhD researchers to mature and retain the next generation of ICT researchers.

- Ensure a reward structure for a research career in ICT that applies across the spectrum and, in particular, is sufficiently flexible to retain Norway's best talents without forcing them to enter into industrial careers.

- Norway invests substantially in research institutes with activities in the ICT area. These institutes appear to be an underutilized resource for education, mentoring and research collaborations and incentives should be developed and implemented to help further develop this.

- An international perspective is essential for Norway and strong international partnerships, providing basic technologies and expertise for the development of its own research, should be cultivated to balance insufficient critical mass in core areas supported in competition with other priorities in a country of its size.

- As an area of national importance, it is recommended that Norway consider initiating a strategic effort to increase national competence in cyber security.

These points and many others in the context of specific groups are expanded upon in the sequel.

The rest of the report is organized as follows: We first offer a general introduction and discuss the mandate for the evaluation committee and list the participating institutions. We make some observations based on the entire evaluation process, followed by more specific recommendations, before concluding with a summary of our broader conclusions. Finally, we evaluate in detail the different departments, research groups, and research institutes covered in this evaluation.

The appendices contain a few details regarding the mandate of the committee and CV's for the evaluation committee members.

2. Introduction

The Division of Science and Technology at the Research Council of Norway has decided to evaluate basic research activities in *Information and Communication Technology (ICT)* at Norwegian universities, university colleges and selected research institutes every 10 years. This report follows two previous such reviews, completed in 1992 and 2002, respectively. The 2012 international review committee of eight was charged with evaluating the area with 62 research groups at six universities, three university colleges, and four research institutes. This report of the evaluation committee aims to help inform the development of future ICT research and funding strategies of the Research Council.

If one accepts the premise that we are living during the digital revolution – a period in which information and communication technology (ICT) continues to transform the organization and operation of human society as dramatically as agriculture and industrial mass production transformed earlier generations – then the future well-being of any nation is vitally dependent on the degrees to which it pioneers new, powerful, and secure information and communication technologies. This must be enabled and complemented by a coordinated and well-funded strategy to prepare and train its citizenry in the use of such emerging technology and to understand the implications of the opportunities offered and choices made and the emergence of new possible threats. In the quest for public attention and support, many "revolutions" are touted as agents of social change and engines of economic development, and justifiably so. What is remarkable about information and communication technology is the way that *it invariably lays at the center of these other revolutions.* For instance, the promise of biotechnology for the improvement of the environment and energy, personalized human health, security, the promise of nanotechnology for the improvement of materials and energy production, and the promise of intelligent systems for everything from traffic control to intelligent energy usage all depend in critical ways on ICT.

Indeed, ICT provides the core enabling technologies for harnessing all other sciences and technologies, in that it ameliorates barriers of distance, scale, and complexity that so quickly otherwise deter our ability to understand and control systems on which our lives and societies increasingly depend. Another profound dimension of ICT is that it not only provides the tools to organize vast amounts of data that are obtained experimentally and empirically, but it also enables the generation, through simulations or sensors, of massive amounts of data that drives a deeper insight into the behavior of systems that may exist only theoretically or are entirely non-physical, e.g., social behavior through social online networks or online recommendation systems. Finally, we note that ICT is a discipline where all of the other disciplines meet for techniques and expertise requirements that they hold in common. A fisheries biologist has little use for a telescope and a structural engineer has little use for a mass spectrometer, but both benefit from advances in data management software or parallel computer hardware that enable them to, respectively, elucidate the structure and expand the level of detail of their physical and abstract scientific universes. It can be argued that lifting the national level of ICT lifts all other technical, scientific, and social disciplines of central importance to a modern nation.

Increasingly, ICT, as an economic locomotive, is progressing beyond its origins in science, technology, defense, security, and business into the consumer and social arenas with the explosion in social networking, online commerce and recommendation systems, and new modes of ICT-enabled collaborative and educational models providing examples that have emerged during the last decade.

Modern society not only depends upon ICT for its survival. It also increasingly turns to ICT for its convenience and pleasure. Digital forms of art and entertainment enrich our lives. ICT is embedded in all walks of life and social behavior through miniaturization and pervasive use of intelligent devices, services and communication technologies to the extent that many areas of industrial development, business and media industry are deeply influenced by such developments. One impact of this *digital convergence* and *ubiquitous* nature of ICT applications is that *software* and associated *computational techniques* have become important engines of social and economic development. However, weaving ICT into all aspects of society, interconnecting the energy supply, critical communication lines, and collections of sensitive information also presents new and very substantial security risks of a nature not seen previously.

Pervasive computing and web-connected embedded systems increasingly enter our lives as consumers and participants in a hyperconnected world. Thus, the marketplace of ICT expands not only outward to increasingly more sophisticated and powerful uses, but also inward, penetrating the lives of people who never conceived of owning a computer, much less of living, moving, and communicating through a web of them. The nation that incubates new uses of ICT creates a steady stream of new high-value jobs and industries that are not dependent upon natural resources but are constantly reinventing themselves.

2.1 Mandate and the review process

This report presents an evaluation of research in Information and Communication Technology (ICT) in Norway, with particular focus on the last ten-year period (2000–2010). The mandate for this review, including its detailed objectives, long-term goals, methods to be employed and specific aspects to be considered, is provided in full in Appendix A. The evaluation committee is presented in Appendix B.

The main objective of this evaluation is to review the overall state of basic research in ICT across Norwegian universities, university colleges and selected research institutes. The evaluation seeks to provide insight and recommendations for the future development of basic research within ICT in Norway, and to represent a foundation on which to determine future priorities, including funding priorities, within and between individual fields of research. Specifically, the international evaluation committee was asked to

1. Provide a critical review of the strengths and weaknesses of basic research in ICT in Norway, both nationally and at the level of departments and individual research groups. The scientific quality should be reviewed in an international context.

2. Identify research groups that have achieved a high international quality level or have the potential to reach such a level.

3. Identify areas of research that need to be strengthened to ensure that Norway will have the necessary competence in areas of national importance.

4. Discuss to what extent the research meets the demand of interdisciplinary research and future societal challenges.

5. Assess the situation with regard to recruitment of PhD candidates in ICT.

6. Assess to what degree the previous evaluations have been used by the institutions in their strategic planning.

The evaluation was conducted based on an overview of factual information (department organization, staffing numbers, graduate production, bibliometric analysis, funding and expenditure) collected in 2011, followed by detailed written self-evaluations from the departments and research groups. During October 2011, hearings were held in Oslo with representatives of the departments and research groups.

2.2 Participants of the evaluation

Universities and university colleges participating in the ICT-evaluation are:

University of Agder (UiA)
Faculty of Engineering and Science
Department of ICT
Faculty of Economics and Social Sciences
Department of Information Systems

University of Bergen (UiB)
Faculty of Mathematics and Natural Sciences
Department of Informatics
Faculty of Social Sciences
Department of Information Science and Media Studies

Gjøvik University College (HiG)
Faculty of Computer Science and Media Technology

Norwegian University of Science and Technology (NTNU)
Faculty of Information Technology, Mathematics and Electrical Engineering (IME)
Department of Computer and Information Science
Department of Electronics and Telecommunications
Department of Engineering Cybernetics
Department of Telematics

University of Oslo (UiO)
Faculty of Mathematics and Natural Sciences
Department of Informatics

University of Stavanger (UiS)

Faculty of Engineering and Natural Science
Department of Computer Science and Electrical Engineering

University of Tromsø (UiT)
Faculty of Science and Technology
Department of Computer Science

Vestfold University College (HiVe)
Faculty of Technology and Maritime Science
Department of Micro- and Nano Systems Technology

Østfold University College (HiØ)
Faculty of Information Technology

Research institutes participating in the ICT-evaluation are:

Norwegian Defense Research Establishment (FFI)

Simula Research Laboratory A/S

SINTEF ICT

University Graduate Center at Kjeller (UNIK)

3. Observations

The following general observations of the state of ICT in Norway can be identified from the reports on Science and Technology Indicators for Norway.

Level of investment in R&D

Norwegian expenditure on research and development (R&D) amounted in nominal terms to NOK 37.4B in 2007. Compared to 2005 this represents a real increase of 17.1%, being the largest increase in R&D expenditure since the mid-1980s. While the current expenditure on R&D in higher education and the research institute sector appears to have been rising during the last decade, the investments are not uniform and growth is more substantial in certain fields. A major growth has been experienced in the area of medicine and health, with investments almost doubling during 2003-2007. The investments in engineering and technology appear to have been fairly steady during 1985 to 2007, although with an increased growth since 2001. Investments in natural and social sciences have likewise grown with a constant pace during the last decade.

In proportion to Gross Domestic Product (GDP), R&D expenditures amount to 1.81% in 2009. In the two preceding years it was closer to 1.6%. This reflects a slight increase compared to 2005 and 2006 where the corresponding proportion of GDP for R&D expenditures share was 1.5%. However, during years 2003 and 2004, R&D expenditures was 1.73% and 1.6% correspondingly. Thus, there is a tendency to a slow relative growth towards the 3%, expressed in the Barcelona agreement.

In spite of this recent growth, Norway continues to underinvest in research and development when compared to its international peers. Current investment levels are well below the R&D expenditures in Sweden (3.62%), Finland (3.96% in 2009), Island (2.8% in 2007), Denmark (3.02% in 2009). Relative to other countries, the relative investment in terms of percentage of GDP remains similar to the one reported in 2002.

The Norwegian higher education sector accounted for NOK 11.7B in R&D in 2007. For the industrial sector and the institute sector in Norway the corresponding numbers were NOK 17.4B and NOK 8.3B, respectively. The relative distribution between these sectors has remained fairly stable since 2005, with a slight increase in the industrial sector's share and a corresponding drop in the research institute sector.

Norwegian involvement and success in attracting EU funding is likewise below that of its peers. We note that the implementation of ideas for co-funding and incentives proposed in the 2002 evaluation have had a positive effect and support that these should be maintained and strengthened.

The major difference in the R&D expenditures among the aforementioned countries is due to investments in the private sector. These are significantly higher in Sweden, Finland, Denmark, USA – in the latter case by a factor of 2 to 3. Furthermore, the gap is widening through a steady decline in Norwegian industry R&D expenditure as a percentage of total R&D expenditure: 43% in 2009, 45% in 2007, 48% in 2005 and 52% in 2003. The investment

in the public sector in Norway is only slightly below that in Sweden, Finland and Island, while it is the same as in USA and is higher than in UK, Ireland and Spain.

R&D productivity

The number of articles published by Norwegian researchers has increased by as much as 74% during the past decade, 1999-2008. In the same period the relative production of articles increased by 24% in Sweden, 34% in Finland and 39% in Denmark. In spite of this tangible growth of productivity and scientific production, Norway remains behind its Nordic neighbors when measured in absolute output, which helps to explain the relatively low international ranking of Norwegian universities as compared to other Nordic countries.

Norwegian articles are cited more often than before, especially within Mathematics, Clinical Medicine, Physics, Agricultural Sciences, and Geosciences. During the 2006–2007 period, Norwegian articles were cited 22% more often than the world average.

More than half of all Norwegian articles in international scientific journals in 2008 were co-authored by foreigners. International collaboration has clearly increased, and there has been a substantial increase in co-authorship with other countries in recent years.

Norwegian patent applications received by the European Patent Office (EPO) amounted to under 0.4% of all EPO patent applications. Swedish applicants accounted for 2,200 EPO patent applications, Finnish applicants for 1,400, Danish applicants for 970, and Norwegian applicants for 430 applications.

The Norwegian system continues to strengthen and is functioning closely enough to the top of international ranks that it could instantly benefit from additional investment. There is no reason that Norway could not rise to the very top internationally in all per capita metrics if funding as a percentage of GDP were increased to more respectable levels, commensurate with its aspirations and relative to its peers. However, structural improvements at the same level of investment can accomplish some of the same benefits of increased investment in the same problem-laden system.

R&D education and workforce

In 2007, approximately 60,000 persons were involved in R&D in Norway with 42,000 being researchers, technicians or other employees with at least five years of higher education. The corresponding numbers for 2005 were 54,000 and 37,000, respectively. The largest increase was related to PhD's and researcher positions in the health-related trusts.

The overall share of female researchers in 2009 was 35% - a small but steady growth in gender diversity is observed compared to the previous years: 34% in 2008, 33% in 2007 (32% in 2005, 29% in 2003 and 28% in 2001). In 2007 the Norwegian higher education sector had up to 42% female researchers, in the institute sector 37% and in the industrial sector nearly 20%.

Percentage of the population with higher education is on a steady rise: 36% in 2008, 34% in 2007, 33% in 2005 and 31% in 2003. It is also observed that this measure is higher than in

Sweden (32%), Denmark (33%), Finland (36%) , EU19 (25%) and OECD (28%). Percentage doctoral degree holders among qualified researchers/scientists have increased substantially over the last decade: 30% in 2009, 28% in 2008, 27% in 2007 and 2005 and 24% in 2003.

In 2007, total R&D personnel accounted for 34,100 person-years, of which nearly 25,000 person-years were performed by researchers and 9,300 by technicians and support staff. In 2005, total personnel accounted for 30,500 person-years, of which 21,700 were performed by researchers and 8,800 by technicians and support staff. In 2003, total personnel accounted for 29,000 person years, of which 21,000 were performed by researchers and 8,000 by technicians or auxiliary personnel.

The number of students in Norway has remained stable from 2002 at approximately 220,000. The number of students studying abroad has declined during the same period before stabilizing during the past three years.

In 2007 the overall number of higher degree candidates at Norwegian higher education institutions was close to 10,000. This represents an increase of 18 % from 2005.

Norwegian institutions of higher learning have awarded a total of 15,000 doctoral degrees over the years. This annual number has increased substantially during the last decade: 1,200 new doctoral degrees were awarded in 2007 (900 in year 2006, 800 in year 2002). Adjusted for the number of inhabitants a few more doctoral degrees were awarded in Norway than in Denmark, but far more doctoral degrees are awarded in Finland and particularly in Sweden. Most of the doctoral degree holders find work within the Government sector, at universities and university colleges. Women made up 45 % of the doctoral graduates in 2008.

A substantial fraction of Norwegian-educated PhD students, in particular in the technical and natural sciences, use Norway as a bridge between their underdeveloped native countries to better-salaried research jobs in the West. This is a tolerable pattern if the main goal of supporting graduate students is putting highly qualified students under Norwegian research faculty for the sake of accomplishing research objectives. However, it continues to represent an opportunity lost for the nation, and, in effect, a subsidy for other advanced countries. Norway has an opportunity to retain more of the researchers it educates with a more competitive salary structure and an increased range of opportunities, enabled by increased national funding, improved mentoring, and some structural changes.

Lack of a national strategy

A national strategic research plan for ICT continues to be missing in Norway. Research areas are often fragmented and not well aligned with Norwegian industry. A bottom-up "free academic" approach is dominating, with the majority of funding from the government and the Research Council going directly to the universities. Although the outcome of this funding is not bad, coordination is lacking and it does not live up to the output achieved in other parts of the world for similar levels of investments.

An obvious strategic area is ICT in life sciences, but also industrial robotics in dangerous environment such as off-shore, and cyber-security. ICT in Energy and Power Engineering also seems also an obvious strategic research area of national interest.

With proper incentives and leadership, the Research Council could lead this work. While it is clear that applications and deployment of ICT will be a central driver for the upcoming years, it remains important to have a basic research competence to be competitive.

However, the size and resources available to Norway suggests that a more strategic approach is needed to maximize research and impact.

Norway needs to strive for excellence rather than covering too many areas. This will also increase the success rate of Norwegian researchers in the competition for EU grants in which Norway (4 Advanced ERC grants/year on average) is currently comparable to Finland, slightly below Denmark (5 Advanced ERC grants/year on average) and with Sweden (12 Advanced ERC grants/year on average) being substantially more successful. Recent initiatives to support the development of these grants by the Research Council have already shown to be successful and should be expanded.

Merit based allocations and rewards

Incentive-based support seems to be catching on among several chairs and deans interviewed as part of the survey, in particular since the 2002 evaluation. The expansion of the Centers of Excellence programs has helped with this situation and the implementation of incentives to encourage the development of EU applications have likewise been steps in the direction of rewarding excellence.

However, the incentives within department and research institutes remain limited, e.g., sponsored trips to conferences or minor sabbatical arrangements, and the differentiation in overall rewards between highly productive and marginally productive faculty is not as large as it perhaps should be. Furthermore, the use of such models for incentivizing excellence is highly non-uniform across universities, university colleges, and research institutes.

There continues to be a general need to establish traditional metrics and to refer to them more frequently than once in ten years at a time of international peer review of entire programs. While such metrics should include citation studies, listings of publications in high quality journals and conferences, and listings of invited international talks, care has to be exercised to ensure that increased volume reflects increased quality.

Another important measure showing impact is the valorization of the research. Although a few startup initiatives were discussed during the interviews, the review committee was left with the impression that research output valorization remains low on the priority list of most institutions. The committee believes this is too important for the Norwegian economy and should be given a higher priority, and activities must be incentivized to promote knowledge transfer and entrepreneurship.

In general, however, such attention to metrics is not easy to motivate if it has little consequence in the reward structure.

Comments on academic workload

Typical teaching load for ICT faculty throughout Norway seems to range from two to four courses per year, occasionally even less than that. As appear to have been the case in 2002,

the committee heard from many faculty members across the academic spectrum, sharing their belief that two courses per year is too high.

This committee disagrees with this, just as the 2002 committee did. A load of two courses per year is entirely consistent with extensive research productivity, even in a research environment in which an increased effort to attract external funding is required. Even the best international institutions usually require at least this much formal teaching. A load of four courses per year is on the border of what would be considered acceptable in much of the rest of the academic research world, but this committee only heard about such a teaching requirement as an exception.

Future faculty development

Except in the very best ICT groups, faculty recruiting is raised as a problem, reflected in too few qualified applicants for each vacancy (often just a few). This appears low relative to the prestige and quality of lifestyle of university personnel and may be somewhat cultural. The committee recommends that institutions implement programs in which graduate students are mentored in their pedagogical skills and given insight into opportunities and challenges for future faculty.

Furthermore, once junior faculty is hired, it is essential that they be guided and mentored by more senior colleagues to help them adapt to and succeed in the academic environment. The committee did not see any coordinated effort to do so, even at the best ICT institutions nationally. It is conceivable that this leads to retention problems and loss of otherwise highly qualified and productive junior faculty. Experiences from the US suggest that such directed mentoring is of particular importance for underrepresented groups, including women in the Norwegian ICT academic world. It is strongly recommended that more formal mentor-mentee programs be established to help mature junior faculty members into successful researchers and professors.

Curriculum and mobility across institutions

Although the committee was not charged with evaluating curricula in any systematic way, we inevitably made some observations on the ICT curriculum, since an academic researcher's life and work closely integrates research and teaching.

University departments in ICT areas are often organized, according to the statements of their own academic leaders (deans and chairs), along curricular lines. Faculty are hired and grouped with a primary eye to covering the curriculum, rather than with a primary eye to creating the highest return on investment through research programs. There are exceptions, and they are noted in the departmental write-ups.

As natural as this may seem, this local organization of research and education appears to have an adverse effect on national mobility. Several universities reported a substantial loss of students during the initial years. However, with a closed 5-year curriculum there is often no natural entry point for students to enter the program at later stages, resulting in a program that appear to be steadily declining. The review panel strongly recommends that this structural problem be addressed to provide clear entry points into the educational pipeline and introduce some level of national coordination among ICT institutions to enable mobility between universities, university colleges, and research institutes.

At university colleges the situation is different since these seem, almost to a rule, to concentrate on nonstandard research niches, to the possible detriment of the students and often with a limited interaction with other institutions. Faculty tends to specialize in areas not well covered by the major universities, possibly to have a chance at becoming national leaders in specialized areas, and the curriculum often reflects this high degree of specialization. An implication of this is that students at the university colleges often do not have access to a standard curriculum of computer science or informatics.

A higher degree of coordination and the development of multiple entry points along the education should allow for a more dynamic education experience while offering students at university colleges access to a broader and more complete set of offerings.

4. Recommendations

The Norwegian research system within ICT is plagued by the same problems that plague many other nations. The rapid increase in the demand for undergraduate and graduate teaching drives inefficiencies in the allocation of resources to growing areas within universities, ad hoc measures to educate the required number of PhDs, and noncompetitive salaries when compared with national and international alternatives. This leads to an area that is struggling to maintain adequate levels, quality and breath of research, and to maintain adequate levels of competent people while continuing to recruit and retain new ones.

Many of these issues are beyond the control of department heads, and competent research managers in the groups and they can only adapt to them through means like seeking funding from industry, arranging possibilities for working abroad, implement minor measure to reward excellent and so on. The responsibility for overcoming serious structural problems in available research funding, salary compensation, and the amount of faculty lies within the national educational and research system. Policy makers within the university system and those who set directions and execute research policies must understand their responsibility. If they want to achieve world-class results in a fast growing, rapidly changing, and strategically important field like ICT, they must provide adequate means to achieve these goals. Therefore the funding for educating the expected number of ICT personnel and the funding for ICT research should be seen as an urgent national priority. As a first step, Norwegian research levels should be made equal (per capita) to those of its Nordic neighbors - Sweden and Finland.

Given the existing resources, incentives, and research environments, Norwegian academic groups and research institutes are doing well in their research efforts. There is a broad, genuine and vigorous effort to engage in high quality research, and most groups surveyed have worked hard to improve quality and develop plans to reach and exceed levels on par with international leaders. The universities generally obtain a satisfactory quality of talented and motivated PhD students, though the domestic supply is not as large as the faculty can accommodate and all but the very strongest research groups experience consistent recruitment problems, in particular at PhD and junior faculty levels.

Nevertheless, there are several disconcerting characteristics in the way in which ICT research is funded and organized across Norwegian universities that adversely affect research output, quality, and scope. This is recognized and discussed in several of the self-evaluation reports in a candid and constructively critical manner. In a rapidly changing, growing, and critical field like information and communication technology negative structural characteristics have a more pronounced influence, even in the short term. If the goal of the Research Council of Norway and Norwegian educational system is to improve the competitiveness of Norwegian research in this field, these issues should be addressed immediately through structural changes.

This observation raises serious concerns since ten years ago, the 2002 evaluation committee made several observations and strong recommendations to address structural problems in Norwegian ICT research and this 2012 committee is discouraged to find that many of these concerns remain valid.

In this section we will offer a number of specific recommendations that the evaluation committee of 2012 finds needs serious attention by policy makers and those responsible for funding and directing national research system. While we note that there has been substantial progress since 2002, we also find the need to reassert a disappointing number of these recommendations.

A new *private* research engineering & life science university at a top location in Oslo could serve as a more substantial change agent in many of these areas of concern. However, the evaluation committee acknowledges that the substantially cultural and political challenges associated with such a development may disallow serious considerations of this.

Continue the formation of groups to enhance collaboration

This is an issue raised in evaluation reports from 1992 and 2002 and continues to be a concern, albeit the 2012 committee finds substantial improvements in this area. Most major research departments are now considerably better organized and with a stronger collaborative structure. This is much less developed at university colleges although one could argue that collaboration at these smaller institutions is even more important.
A stronger group structure has a number of advantages apart for increasing research focus as it allows improved coordination of teaching, sabbaticals, and increased intellectual strength needed for the development of large-scale research proposals.

We do see a need to repeat the recommendation of 1992 and 2002 that larger groups with a long term research focus are helpful in attaining the goal of having internationally visible, multigenerational research activities, and providing sufficient critical mass, wherein students in effect teach each other and leverage off of each other's work.

Such a structure and focus also provides exciting opportunities for postdoctoral researchers and junior faculty members, helping to lift one of the major challenges facing Norwegian ICT research - the creation of the next generations of ICT researchers and leaders.

The Center of Excellence program has been very effective in building national groups around excellence and should be continued. However, sustainability of these activities after the end of funding is emerging as a problem that requires attention by university leaders and those responsible for research funding.

Continue to focus on research quality and improve publication in quality and quantity

The 2012 review committee finds a considerable increase in the production of papers and conference proceedings since 2002 as well as an expanded focus on a higher quality of publications. The increased focus on metrics since 2002 has helped improve the situation.

However, we also find that many groups continue to fall below international standards in quantity and, in particular, in quality of research output. As discussed in the 1992 and 2002 reports, this is attributable to numerous circumstances, e.g., insularity, lack of critical mass within a research area, or lack of long-term focus in research teams.

The committee recommends that publication outputs be measured at regular intervals in time and in relation to international standard levels within the same fields among a group of peer countries. More flexible quality indicators in university funding than just the number of

journal publications in two categories should be implemented. Such efforts should help to incentivize increased focus on publishing in internationally recognized research outlets.

Plan for generation change and focus on successful recruitment of senior personnel

The review committee met with a number of research groups faced with substantial generational change expected during the next decade. It is essential that this be done in a planned and forward-looking manner and not simply by internal recruitment and replacement within existing fields. Departments should develop strategic plans for the challenges and opportunities for renewal in research focus offered by such changes.

It is essential that recruitment of new faculty members is done broadly and with an international focus, in particular when candidates for senior positions are sought.

There is no reason why Norway cannot be as attractive as Switzerland when recruiting research leaders. This has already been demonstrated by Simula Research Laboratory, which has shown considerable success with international recruiting. These experiences should be shared nationally to understand how to overcome possible barriers and understand international levels of compensation.

Develop and implement standard guidelines and procedures for promotion and tenure

Previous evaluations have noted that a number of faculty members in departments with aspirations to train significant numbers of PhDs lack PhDs themselves. The 2012 review committee finds that this situation has improved substantially and we expect it will soon cease to be a concern.

However, we continue to find significant “academic inbreeding” wherein PhDs are immediately hired and in some cases strongly preferred by their own institution. While this appears to be a particular problem at university colleges, it also reaches into more established institutions.

We concur with previous evaluation teams that significant caution must be exercised in filling faculty positions with internal candidates, as this constitutes a mortgage for several academic generations under Norway’s current policy of systematic promotion through the academic ranks. As a minimum, local candidates should be required to spend substantial time in a different research environment, preferably internationally, before being hired into a permanent position.

The committee also recommends that clear and transparent guidelines for promotion and tenure be implemented across all institutions to clarify measurable expectations for junior faculty members to advance in the academic system.

Encourage research time abroad through sabbatical arrangements

The use of faculty sabbaticals remains something that is offered non-uniformly across the Norwegian academic system. Some universities provide sabbatical opportunities frequently (e.g., every fifth or six year) and the faculty takes the obligation to spend it abroad seriously. At other institutions this is less used, often due to financial restrictions. Some institutions,

e.g., NTNU and University of Tromsø, are experimenting with several alternative models that could be adapted as national models.

In line with previous evaluations, we strongly recommend that the use of sabbatical leaves be implemented and funded as an option across the academic enterprise in a uniform manner to enrich research at Norwegian universities and research institutes.

Form a Norwegian informatics curriculum and implement more flexible education structure

University departments in ICT areas are often organized, according to the statements of their own academic leaders (deans and chairs), along curricular lines. Faculty are hired and grouped with a primary eye to covering the curriculum, rather than with a primary eye to creating high value research programs. As natural as this may seem, this local organization of research and education appears to have an adverse effect on national mobility. Several universities reported a substantial loss of students during the initial years. However, with a closed 5-year curriculum there are typically no natural entry point for students to enter the program at later stages, resulting in program that appear to be steadily declining. The review panel strongly recommends that this structural problem be addressed by providing clear entry points into the educational pipeline, possibly through a national implementation of a 3+2 model, and to introduce some level of national coordination among ICT institutions to enable mobility.

This is perhaps even more important for students at university colleges, which often concentrate on nonstandard research niches. An implication of this is that students at the university colleges often do not have access to a standard curriculum of computer science or informatics. A higher degree of coordination and multiple entry points along the education should allow for a more dynamic educational experience while offering students at university colleges access to a broader and more complete set of course offerings, and research opportunities at research institutes.

Coordinated Infrastructure purchase, maintenance and support

Several interviewed research groups raised concerns about maintenance and support of expensive and in many cases unique experimental facilities, essential to their research and the educational mission. This presents a substantial threat to research leadership across many ICT disciplines and should be urgently addressed.

Furthermore, in many fields the infrastructure cost is becoming so high, that it no longer makes sense that each university buys and operates similar equipment. Rather, a model should be developed to enable institutions to buy the "services" at other institutions. This naturally has to be implemented in a careful manner to balance competitions and the financial implications.

It is alarming that an almost similar situation was noted in the 2002 report and only limited progress appears to have been made. As then, laboratory facilities (e.g., clean rooms, bioinformatics laboratories, telecommunications facilities) and large scale computational resources continues to demand major investments while departments are reducing their operational budgets, effectively choking the effective and long term use of these facilities.

The committee finds that the Research Council needs to take leadership in this process with some urgency and develop programs for national equipment purchase, maintenance and support, as well as help implement a model for more effective use of shared infrastructure across universities, university colleges, and research institutes.

Organize PhD education through national PhD schools

Generally, universities fund PhD students through internal or external funds and students are accepted through some screening process that is typically reasonably formalized. Students are then expected to work in some research groups or by themselves. There is very little, if any, organized education programs offered as part of the PhD education and students are not admitted to formally organized "schools" or "programs". Consequently, there is limited emphasis on developing systematic practices at the departmental level to control the progress of the PhD students through the program (e.g., advising groups of multiple faculty, and departmental exams) and exercise a broader level of quality control. A notable exception to this is NTNU which appears well on its was to implement a more structured and formalized approach.

PhD students are not reflected as a major part in the Norwegian R&D budget at the universities and research institutes. They do, however, carry out a bulk of the research work and output. The lack of national coordination and quality control is potentially a major concern since it results in varying quality of PhDs produced (in terms of their methodological, technical, and communication skills). Addressing minimum quality requirements for PhD programs and forecasting their resource requirements are critical policy issues in order to improve future competitiveness of the Norwegian research system.

In line with the 2002 recommendations, we believe that without such measures it will be very difficult to adequately increase the production and quality of PhDs to the level required by both Norwegian industry and the research institutions.

One way to improve the situation would be to allocate special funds to support National Research Schools promoting PhD education in selected areas. Models for such national schools exist in the other Nordic and European countries.

Take advantage of distance learning and high-speed networks to benefit from local expertise in education and research

The 2012 review team agrees with previous evaluations that, as a country with a large geographical spread and a relatively small population, Norway stands to gain more than most countries from the exploitation of high-speed networking, efficient use of modern telecommunication and networked and blended learning models.

Norwegian universities and research institutes do not seem to be oriented towards distance education with the notable exception of UNIK. We encourage Norwegian ICT groups to lead the national science and engineering community in embracing network technologies for tele-presence of all kinds – distance education, new educational models, sharing seminars nationally, and international collaboration. At this time, there are many examples of such activities across EU and the US and it is a rapidly growing segment of the educational and research enterprise internationally.

Such technologies can also be used to overcome the limitations in group size and paucity of research talent and leadership across many areas of ICT research and enable a much needed stronger integration of the research institutes into the educational and research activities at the universities and university colleges.

Expand funding for postdoctoral researchers across ICT

The use of postdoctoral researchers across the ICT landscape appears to be non-uniform. The committee sees this as being unfortunate since postdoctoral researchers can play an important role in numerous areas and help alleviate pressure points, i.e., they offer an opportunity to help out distributing the work load, can combine their own research with mentoring PhD students towards some project goals and they can lead to an improved utilization of expensive and unique experimental facilities.

On the other hand, quantity in postdoctoral researchers is not enough. There needs to be a career track and a positive job outlook for these postdoctoral researchers, and industry, universities and research institutes must come to appreciate the value of a postdoctoral experience.

The committee recommends that postdoctoral researchers be funded at an increased level, in particular to further strengthen research groups that are very active and visible.

Initiatives to increase interest in ICT education and research among Norwegian students

While the challenges associated with attracting students into ICT areas is one shared with Western Europe and USA, it is a particular problem for smaller countries such as Norway. Addressing this problem requires substantial and urgent attention throughout the academic enterprise, reaching into the elementary school system to raise interest in engineering, science and technology – an interest that is often initiated at as young an age as 8 to 10.

The Research Council could play a leadership role in this by emphasizing the need and importance of outreach and public events as part of major research initiatives such as Centers of Excellence.

Increase incentives for valorization of research results

Another important measure of impact is the valorization of research results. Indeed, education, research and innovation form a triangle, well recognized in other countries and even being the explicit focus of the European Institute of Technology (EIT). Although a few startup initiatives were discussed during the interviews, the evaluation committee was left with the impression that ICT research output valorization remains low on the priority list of most institutions in Norway. The committee finds this to be too important for the Norwegian economy to ignore, as it may lead to many high-value jobs, and should be given a higher priority.

It is strongly recommended that an innovation strategy and supporting incentives be developed – also within universities and research institutes - towards the economic valorization of ICT research results, encouraging entrepreneurship and promoting transfer of knowledge to existing or new (startup) companies. To avoid conflicts with other tasks, it is also recommended that activities in research valorization be an explicit additional metric in faculty evaluation.

Focus on development of mentor plans and support for young faculty members

With the general message that faculty recruiting is a problem, in the sense that there are too few applicants for each vacancy (often just a few), the review committee is concerned about what it perceives as an almost complete lack of attention to the importance of mentorship of junior faculty. The committee notes with concern that while it saw impressive research achievements by senior researchers, it was introduced to a much smaller number of upcoming stars.

Once junior faculty is hired it is essential that they be guided and mentored by more senior colleagues to help them adapt to the academic environment. The committee did not see any coordinated effort to do so, even at the best ICT institutions. Such lack of mentoring and support may well lead to retention problems and loss of otherwise highly qualified and productive junior faculty. Experiences from the US suggest that this is of particular importance for underrepresented groups, including women in the Norwegian ICT academic world. It is strongly recommended that more formal mentor-mentee programs be established to help mentor and mature junior faculty members into successful researchers and professors.

It is likewise of importance that the Research Council establishes and maintains programs focused on funding young researchers in strategic research fields and to help them on the path to seek more substantial EU funding.

Expand and incentivize increased domestic cooperation in research and education

The Norwegian research system is very heterogeneous and distributed, and as a result there are few groups with truly comfortable critical mass. This is further complicated by the system of research institutes, some of which have grown substantially during the last decade. These research institutes engage in PhD education, although with limited direct responsibilities in this process the research experience.

Most cooperation between different universities and research groups takes place currently through sharing adjuncts ("Professor II") across departments and research institutes. This may indeed be a good model for such collaborations although care has to be exercised on how these are managed and financed to ensure impact at both institutions.

However, few attempts were seen to organize cooperation at the level of providing joint doctoral courses, seminars, workshops, or organizing mutual mentoring relationships for the doctoral education. In a small country with only a few strong research groups scattered around the universities in each area, such a situation is not beneficial. It decreases the level of exploitation and utilization of resources, impedes networking between PhD students and researchers with similar interests, impedes and limits access to top level international research, and thereby over time keeps research quality and quantity from reaching its full potential.

The committee is concerned to see what it perceives as a slow but increasing separation between universities and research institutes, in particular the major ones, SINTEF and

Simula. The base funding of SINTEF has reached a level so low that it impedes its ability to justify fundamental research and extensive university collaborations. The path of Simula Research Laboratory appears to be one of increasing internationalization at the possible expense of national collaboration and involvement in education.

Both developments are unfortunate as they eliminate the effective and highly attractive involvement of the research institutes across the entire education enterprise, including offering staff for courses and co-advising at universities across the country. This is perhaps a particular concern with Simula Research Laboratory with its substantial national funding, yet with a strong focus on the University of Oslo and an expanding international partnership at the possible expense of exploring the potential of the use of the resources to achieve a much broader national impact.

Resources, and incentives that increase cooperation and research activities between the universities should be made available at the national level. The committee also feels that departments should be more proactive in initiating such activities, and insulation between different departments and groups should be strongly discouraged and actively disincentivized. Such networks should be orthogonal to the research projects, and should not reduce intellectual freedom in individual research projects.

Recognize and reward excellence

While substantial improvements in this area have been made during the last decade, the 2012 review committee feels a need to highlight this as a continuing concern. The Norwegian research system does not recognize and reward world-class research and research groups, as it should, perhaps with the exception of Simula Research Laboratory where resources are better aligned with this.

The Center of Excellence program has been very effective in building national groups around excellence and should be continued. However, this concern is not only aimed at providing adequate research funds to excel; it also deals with how talented people are compensated in a highly competitive area of expertise. More flexible and performance- based compensation schemes should be made available and installed to reward world-class performance.

Continue to increase PhD production

While the output of PhDs within the Norwegian research system has increased substantially during the last decade, an overcapacity of supervising resources remains in many places. Furthermore, with the approaching generational changes, the production of PhDs is below adequate level to meet the demands of replacements, substantial growth in the field and emerging demands of the industry.

This requires that more active measures in funding be made available for the departments, and a more systematic approach to the organization and management of PhD education. However, it is important that this be supplemented by making the value of a PhD clearer to industry. Departments should market their PhDs more actively to industry and there should be national policies that improve the placement of PhDs into industry. The establishment of a formal industrial PhD system could be helpful in this respect and models can be found in neighboring countries.

Once industry appreciates the value of a PhD, it is likely that the number of national candidates will begin to increase and the value to postdoctoral experiences is likewise likely to see increased appreciation.

Generate incentives to researchers for participation in international research programs

The establishment of generous incentives to promote EU proposals is an excellent example of the kind of programs that should be expanded (both as participant to and as coordinator of projects) to promote participation in international research programs, including the EU framework programs and programs like ERC and ESF. Special opportunities for junior researchers should be developed. These programs should be merit based, more favoring successful applications, and should strive to lift both education and research.

A more direct involvement of SINTEF to provide leadership and guidance on this appears to be an opportunity.

5. Concluding Remarks

We present a set of broad recommendations that aim to address concerns in the national interest of Norway and to position Norway to exercise international scientific leadership in vital areas of ICT.

- Develop a national ICT research strategy that focuses on technical excellence, that balances established and emerging areas, and that considers the peculiarities of the Norwegian industry and society in addition to the global international context.

- University departments and research institutes in ICT should be encouraged to compare their research areas and their research productivity annually with a set of leading peer organizations outside of Norway.

- Develop or strengthen an innovation strategy with supporting incentives – also within universities and research centers - towards the economic valorization of ICT research results, encouraging entrepreneurship and fostering transfer of knowledge to existing or new (startup) companies and the creation of high-value jobs in ICT.

- ICT organizations should seek to better coordinate their educational offerings, flow of personnel, construction and support of facilities. For a small country like Norway, this has to be a balance between fostering healthy competition and achieving efficiencies of scale.

- Increase national coordination of PhD education to ensure uniform quality and increase mobility, and help establish networks among young researchers.

- Enhance awareness of the critical importance of mentoring and training of junior post PhD researchers to mature the next generation of ICT researchers.

- Ensure a reward structure for a research career in ICT that applies across the spectrum and, in particular, is sufficiently flexible to retain Norway's best talents without forcing them to enter into industrial careers.

- Norway invests substantially in research institutes with activities in the ICT area. These institutes appear to be an underutilized resource for education, mentoring and research collaborations and incentives to enhance this should be developed and implemented.

- An international perspective is essential for Norway and strong international partnerships, providing basic technologies and expertise for the development of its own research, should be cultivated to balance insufficient critical mass in core areas supported in competition with other priorities in a country of its size.

- As an area of national importance, it is recommended that Norway consider initiating a strategic effort to increase national competence in cyber security.

6. Evaluation of Departments and Research Groups

In the following we offer a more detailed discussion of each of the university and university college departments, at the level of research groups and provide some specific recommendations that we hope to be useful going forward.

Following the tradition of previous evaluations, we have assigned a grade to each research group, reflecting our view on the qualities, challenges and opportunities we were left with after the self-evaluations, interviews, and discussions. These grades, ranging from 5 (international leadership, visibility, and vision) to 1 (substantial structural problems and limited impact and productivity), are assigned in a relative fashion across the groups.

The evaluation committee wishes to emphasize that we have not had information about how grades were assigned in past evaluations and ask that grades not be compared across the 1992, 2002, and 2012 evaluations as the metrics are likely different.

6.1 University of Agder

6.1.1 Department of ICT

The department of ICT is part of the Faculty of Engineering and Science. It is a large department that consists of 59 members including 7 professors, 3 associate professors, 2 adjunct professors, 1 adjunct associate professor, 6 senior lecturers, 7 lecturers, one postdoctoral researcher, 22 PhD students and 10 technical and administrative positions. The department offers an integrated MSc and PhD programs that aim to facilitate the recruitment of master students to doctoral studies. The department is organized in three so-called competence groups namely, mobile communication systems, system development and security and multimedia with three shared application domains in e-health, technology based education and mobile communications in crisis situations.

Assessment

The University College of Agder became a University in 2007. The three application areas are work in progress. The matrix structure established in 2007 seems to have played a positive role in this process. The research productivity of the department is very high and significantly above the average of all units covered by this evaluation. However, the department considers teaching to be an important pillar in its activities and some group members do not have strong research ambitions. External funding is important but EU funding is low. The number of supervised PhD students since 2006 (date of PhD program creation) is satisfactory.

Recommendations

The committee offers the following recommendations

- Improve the balance between research and teaching and increases postdoctoral researchers as means to enhance the shift of the department toward research.
- Recruitment of PhD students from local master students shall be limited and the committee suggests focusing on outside rather than inside.
- Increasing EU focus.

Mobile communication systems group

This group is composed of 2 professors, 1 senior lecturer, 2 lecturers and 10 doctoral students. It focuses its research in channel modeling, ad-hoc communication systems and protocols, and electronics and embedded systems.

Assessment

This is by far the strongest group within the department with a total number of publications per number of FTE (full time equivalent) of 14.3, which is far above the average of groups involved in this evaluation (1.56). However, performance in terms of citations is below world average in this area of research. The group carries out research in a very individual manner and without well-established common goal.

Grade: 4

Recommendations

The committee offers the following recommendations

- Increase internal synergy among the different researchers working on different topics within the mobile communication systems group.
- Reorient its research portfolio towards national interests and increase its connections with industry.
- Improve the international outlook.

System development and security group

This group is composed of 4 professors, 2 associate professors, 2 adjunct professors and 1 adjunct associate professor, 1 senior lecturer, 1 lecturer, 1 post-doctoral fellow and 9 PhD students. The group focuses research on some areas of artificial intelligence and on the use of modeling within system development with a main focus on security and trust.

Assessment

The system development and security group has a broad project portfolio including EU funded projects. It is successful in raising external funds, in particular from National Research Council. The quantity and quality of publications is good but the performance in terms of citations is very low (see report produced by the Council). The number of supervised PhD students is satisfactory.

Grade: 3

Recommendations

The committee offers the following recommendations

- The group consists of individual activities and should strive to enhance internal synergy.
- The industry connections play an important role and an effort should be made to maintain and increase these.
- The number of supervised PhD students should be increased.
- Hiring of postdoctoral researchers will help the group leveraging its publication quality.

Multimedia group

This group consists of 1 professor and 1 associate professor, 4 senior lecturers and 4 lecturers and 3 PhD students. The research is focused on designing and implementing advanced multimedia solutions.

Assessment

The group is in a transition period with a current strong focus on teaching. The productivity is low with an average of 1.5 publications per number of FTE (Full Time Equivalent), which is about the average for all units covered by the evaluation. The group has connections with local industry.

Grade: 2

Recommendations

The committee offers the following recommendations

- Seek to identify the research profile of the group and to further define its focus.
- Increase publication activity.

6.1.2 Department of Information Systems

The department of Information Systems is part of the Faculty of Economics and Social Sciences. It comprises 3 professors, 11 associate professors, 3 adjunct professors, 11 PhD students and 2 technical/administrative positions. The department offers a three-year bachelor program, a two-year MSc program and three-year PhD program (since 2009) all with a focus on Information Systems. The research area is on Information systems broadly with three specializations on eGovernment, enterprise systems and information systems development under the responsibility of three research groups, namely the Centre for eGovernment (CeG), the Centre for Enterprise Systems (CENS) and the Research Group for Information Systems Development (ISD). The department became a member of ERCIS in 2011.

Assessment

The department is successfully but partially engaged in a shift of focus from teaching to research. The number of publications has increased during the last decade and the department is aware of the need to increase focus on high-level publications. The PhD program is well on track with 11 students currently enrolled. The department has expanded its international relationships and organized several international and national workshops and conferences. External funding is relatively low and EU funding insufficient.

Recommendations

Leveraging the research competencies of the permanent staff have been a department goal during the reporting period and remains a key challenge for the department. The evaluation committee recommends continuing to increase the focus on research. We see a risk of expanding the spectrum of research topics too much and recommend more focus in the research profile. As identified by the department, the level of publications shall increase. The department is still in a transition phase and the committee recommends hiring postdoctoral researchers and enhancing the use of sabbatical leave as means to accelerate the shift to a more pronounced research focus.

The centre for e-government

This centre consists of 1 professor, 4 associate professors and 6 PhD students. It was established in 2011 as a continuation of the research group of the same name created in 2001. The group deals with e-Government in the large with specializations on benefits-realization, e-participation and ICT for development.

Assessment

The group performs applied research that is practice oriented and practical problem solving. The work is conducted within projects funded locally and regionally. In addition, the group has been able to attract external funding from the Research Council of Norway and participates in one EU project. The group has established good connections with industry and the public sector and with other universities in Norway, Scandinavia and abroad with Tanzania and Nepal. The publication performance is increasing.

Grade: 3

Recommendations

The committee offers the following recommendations

- The evaluation committee recognizes the importance of the research domain and recommends maintaining the focus on some key topics within the area of e-government.

- The quantity and quality of publications shall increase and to achieve this objective the committee recommends increasing focus on external funding.

The centre for enterprise systems

This centre is composed of 1 professor, 3 associate professor and 2 doctoral students. It was created in 2007 and is considered to be one of the strategic areas of the department. The activity focuses on enterprise systems acquisition and implementation, teaching methodology for enterprise systems, business process management and process modeling, inter-organizational relations and, knowledge management and e-collaboration.

Assessment

The group conducts empirical studies and surveys to better understand how enterprise systems shall be acquired and implemented in SMEs. It has also a strong emphasis on gaining knowledge to teach students and train SMEs. The group has a satisfactory publication output with a reasonable number of articles at level 1 and 2 IS journals. International cooperation exists but could be strengthen. External funding is too low.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- Given the small size of the group and the breath of topics, the evaluation committee recommends increasing focus.
- A competitive research strategy should be developed to enhance the publication quality.
- Increased emphasis on external funding.

The ISD group

The ISD group comprises 1 professor, 4 associate professors, 1 adjunct professor, 1 assistant professor and 2 PhD students. It was established in 2000. The research area is Information System Development (ISD) with a focus on four topics: ISD practice, pedagogical challenges of ISD teaching, organizational implementation of IS in organizations, and free and open source software.

Assessment

The research topics of the group's members are mainly determined by their teaching obligations. The group lacks a focused research strategy and common research projects. External funding is insufficient. The group is mainly involved in teaching with only 10% of the time dedicated to research. Consequently the publication performance remains moderate despite an increased FTE per person activity in the recent period.

Grade: 2

Recommendations

The committee offers the following recommendations

- The evaluation committee sees leveraging the research competencies of part of the permanent staff as a key challenge for the group. The committee acknowledges the difficulties of the group as such to carry out research and recommends increasing coherence and focus.

- Raise its ambition level and increase publications flow and quality.

- Increase attention to external funding opportunities.

6.2 University of Bergen

6.2.1 Department of Informatics

Established in 1984, the Department of Informatics has grown steadily and dynamically over the years. Currently, the department has 22 faculty members divided into six groups. Additionally, 41 PhD students as well as 23 postdoctoral researchers work in these research units. Among the six groups, the following five participate in the current ICT evaluation: Algorithms, Optimization, Programming Technology, the Selmer Center, and Visualization. The Visualization group was founded five years ago and is hence relatively new. A sixth group on Bioinformatics was assessed within the Evaluation of Biology, Clinical Medicine and Health Science. A former group on Numerical Analysis, which was reviewed in 2002, merged with the groups in Industrial Mathematics and Fluid Mechanics & Ocean Modeling in the Department of Mathematics. Consequently, 5 faculty members moved from Informatics to Mathematics. The Department of Informatics hosts the high performance computer facilities of the University of Bergen, organized in Parallab. Moreover, the department has been a driving force in the development of infrastructure for eScience in Norway.

Assessment

The overall performance of the Department of Informatics is very good to excellent. The department is not large enough to cover all fields of informatics. However, the existing groups are very productive and have worked successfully during the last years. Several groups perform cutting-edge research and enjoy strong international recognition and visibility. In general, the department strives for scientific excellence in its selected research areas. Several groups emphasize theory-oriented basic research in informatics, which is almost unique and thus a national strength within Norway. On the other hand, the corresponding groups have relatively few ties with other Norwegian universities.

The department members publish actively in high-quality international conferences and journals. They have also been very successful in acquiring external funding, mostly from the RCN but also from the EU as well as other public and private sources. Presently, more than 40% of the department's total expenditures are covered by external grants. Remarkably, the number of PhD students and postdoctoral researchers has increased over the last years. Among the 41 doctoral students, 22 are funded externally; among the 23 postdoctoral fellows, 19 are financed through external sources. Last not least, the department has been successful in recruiting strong faculty members with half of the professors having an international background.

Recommendations

The department faces a generation change and an associated challenge. During the next years, 6 faculty members will retire. The department can only maintain its strength if it is able to appoint excellent scientists. The committee recommends that these hiring processes be prepared early and carefully. The department should identify promising research directions and potential candidates with a strong scientific profile and international experience.

While the individual groups are currently very strong, there is little interaction between the units. This is unfortunate because some of the groups have related research foci, in particular as far as theory-oriented work is concerned. The committee recommends that steps be taken to improve the collaboration and to build synergies among the groups. Such corporations can prove beneficial when applying for larger grants involving several teams. Finally, the department members have been successful in acquiring external funding. It would be desirable to strengthen the internal incentive system in this respect.

Algorithms group

The group consists of 4 professors, 5 postdoctoral researchers and 6 PhD students. Its research addresses the theoretical foundations of algorithm design. More specifically, the group investigates computational intractability, exploring parameterized and exact exponential time algorithms. Furthermore, the group studies approaches to exploit structure in computationally hard problems as well as sparse matrix computation. The team forms a coherent unit in which the research interests of the individual members complement each other very well.

Assessment

The Algorithms Group exhibits an excellent performance, which has improved since the last evaluation. Most notably, the group was awarded an ERC Advanced Grant and a tenure track grant from the Bergen Research Foundation. In general, the group members are very active and perform high-level research. Over the last years, they have published 159 conference papers and 70 journal articles. This includes many contributions in the most prestigious and selective venues. The productivity in terms of quality and quantity is excellent. The scientists enjoy a high international visibility. They are frequently invited to serve on the program committees of leading conferences and, moreover, have also organized important algorithms conferences in Bergen during the last 10 years. From 2008 to 2010, 6 PhD students completed their degree, which is viewed as a very good result. The group has generally been very successful in obtaining external funding. In fact, at the moment, all of the postdoctoral researchers are financed by external grants.

Grade: 5

Recommendations

The committee offers the following recommendations

- Broaden the scientific scope beyond computational intractability. Use the current momentum and reach out to a related research topic, enhanced, for instance, by hiring a junior scientist who can do independent research on an interrelated theme.

- Encourage the team to apply for a National Center of Excellence in the near future.

Optimization group

Due to a retirement in 2005, the group is presently very small. It comprises 1 professor, 1 associate professor, 1 postdoctoral researcher and 2 PhD students. The group members pursue both theoretical and applied research in continuous and combinatorial optimization. The basic research addresses modeling issues and the design of new solutions methods. The applied work covers a spectrum of applications, including vehicle routing, transportation of gas in pipeline networks, and the layout of wind farms.

Assessment

The group has high standards and pursues an attractive combination of theoretical and applied research. It is very positive that it acquired a number of very interesting industrial projects, dealing e.g. with the design of offshore wind farms. The publication record is good. In the period from 2006 to 2010, a total of 31 journal articles, 26 conferences papers as well as one monograph were published. From 2008 to 2010, 4 PhD students completed their degree. Over the last ten years, the group graduated 11 PhDs, many of whom now hold positions at well-known academic institutions. The team is very well connected. It maintains active collaboration within the University of Bergen and various partners on the national and international level.

Grade: 4

Recommendations

The committee offers the following recommendations

- Historically this group has been very strong but in the current constellation, with only two professors, it is not robust and a strategy for renewal is needed, possibly by hiring a new strong faculty member as soon as possible.

- Alternatively, the group seeks to merge with another group in the department; a possible candidate is the Algorithms Group.

- Emphasis on trying to attract EU funding.

Programming technology group

The Programming Technology Group consist of 2 professors, 3 associate professors, 1 adjunct professor, 1 adjunct associate professor as well as 2 postdoctoral researchers and 6 PhD students. Its research concentrates on logic, algebra and category theory for software engineering and web security. Furthermore, the group investigates programming language design and develops tools. The research activities are organized around various ongoing projects.

Assessment

The group pursues a good combination of theoretical and applied research. It covers an interesting array of topics but, unfortunately, does not cover important themes related to embedded systems and distributed computing. The overall performance of the team is good to very good. From 2006 to 2010 the group members published 38 conference papers and 25 journal articles, many of which appeared in level-2 journals. The group has been successful in obtaining external funding, mostly from the RCN. In particular, it built up the Bergen Language Design Laboratory as part of RCN funded projects. Furthermore, both postdoctoral researchers are currently financed by external grants. In the reporting period the group supervised the largest number of Master's students in the department. Moreover, from 2008 to 2010 it graduated 4 PhD students. The group maintains a good network of scientific partners and recently organized two major international conferences in Bergen.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- Broaden the scientific scope to incorporate research areas related to embedded systems and distributed computing.
- Focus on increased publication in highest quality journals.
- Increase coordination, which may lead to more synergies within the team and with other groups of the department.

Selmer center

Within the department the Selmer Center forms the largest research unit, consisting of 6 professors, 9 postdoctoral researchers and researchers as well as 8 PhD students. It is devoted to research in reliable and secure communications and emphasizes theoretical studies. The investigations cover a broad spectrum of topics in fundamental fields such as information theory, cryptography and information security. The scientists work in three corresponding subgroups with overlapping research interests.

Assessment

The Selmer Center is an internationally renowned research group that has done outstanding work for decades. The staff works on challenging research problems and has made significant progress towards resolving extremely hard open questions. The productivity is impressive, in terms of both quality and quantity. Since 2006 the group has published a remarkable number of 96 journal articles and 125 conference papers. This includes many contributions in top international venues and, in particular, numerous papers in the flagship journal IEEE Transactions on Information Theory. The group has been very successful in acquiring external funding, mostly from the RCN and the EU. It also received a grant as a Marie Curie Training Site. Since 2008 10 PhD students graduated in the center. The group members have been active organizing international workshops and conferences. They frequently serve on the programming committees of leading conference and also act as associate editors of prestigious journals.

Grade: 5

Recommendations

The committee offers the following recommendations

- The pending retirement of two very distinguished group members is a serious threat to the continued success of the Center. Concrete plans for how to cope with this generation change are urgently needed.

- The group expands its activities in the area of security as an emerging field with significant importance and growth.

Visualization group

The Visualization Group was established in 2006/07 and has been built up with a considerable amount of effort since. Consisting of only 1 professor, 1 associate professor and 1 postdoctoral researcher, the group remains small. However, including 2 additional adjunct associate professors and 8 PhD students, the team has the critical mass to operate as a very well respected unit. The research focuses on visual computing and knowledge-based visualization. More specifically, it addresses the efficient visualization of large and complex data for the purpose of data exploration and analysis.

Assessment

The evaluation committee acknowledges the effort and dedication invested to establish this group. The recruitment on the international level has been very successful. The group members are very active, highly motivated and enthusiastic about their mission. The research agenda is attractive and includes interesting visualization projects in medicine, biology, meteorology and the geosciences. The accomplishments made so far are excellent. Since 2007 group members have published 69 papers, many of which are highly cited and appeared in level-2 journals. Within a short period of time the team has obtained a considerable amount of external funding from the RCN, the EU and industrial partners. In particular, the group coordinates a FET-Open project. The group maintains a strong network of partners, nationally and internationally. It has graduated its first two PhDs and recently organized the major European visualization conference.

Grade: 4-5

Recommendations

The committee offers the following recommendations

- The group must seek to stabilize during the next years and strengthens and grow its infrastructure.
- The group should broaden the range of investigated applications, seeking to open up new avenues for interesting research and accompanied projects.
- Visual analytics is a rapidly growing field and the group has the potential to make a significant impact by increase industrial collaborations.

6.2.2 Department of Information Science and Media Studies

The Department of Information Science was established in 1974. In 2004 it merged with the Department of Media Science, based on common research interests. The department is hosted in the Faculty of Social Sciences. It currently consists of 11 faculty members and 14 PhD students working in three groups. The mission of the department is to study the role of technology in information and communications systems from a social science perspective. The research has a technological focus and includes the use of formal methods to manage knowledge and information. It addresses the development and evaluation of information systems that are based on social and semantic technologies. Moreover, the department is interested in human-centered methods for designing information systems in a variety of new applications.

Assessment

The department pursues interesting and timely interdisciplinary research. The overall performance is good. From 2006 to 2010, department members published 127 conference papers, 37 journal articles as well as 18 book chapters and 2 books. This is a good productivity but the number of journal publications could be improved. The department receives low basic funding. It does not have resources to hire scientific staff for software development. The groups are involved in a number of externally funded projects and the volume of external grants has doubled over the last three years. However, the external funds are still below 20% of the total research expenditures. Since 2008 a total of 8 PhD students completed their degree. Strengths of the department are the Bachelor's and Master's students. From 2008 to 2010, 88 Bachelor's and 56 Master's degrees were conferred. The corresponding students are very attractive to the regional and national industry. The department maintains an extensive network of collaborations on the national and international level.

Recommendations

There is an imbalance with respect to conference and journal publications. The department should increase the number of contributions published in international journals. The committee strongly recommends hiring postdoctoral researchers, who are missing in the current staff structure. Furthermore, the department should seek to increase its external funding. It would be desirable if the department took the leadership and acquired a larger project, possibly funded by the EU that is coordinated within the department. The committee also feels that the groups could strengthen their synergies and, moreover, intensify their collaboration with the Department of Informatics; potential partners are the groups on Visualization and Programming Technology. In general, it would be wise if the department sharpened its strategic objectives specifying where it intends to stand in 5 or 10 years.

Interaction research group

The group comprises 2 professors, 1 associate professor and 4 PhD students. Its research addresses the design, development and evaluation of technology supporting interaction. The work is organized around several projects in the fields of human-computer interaction, computer supported learning & education and computer supported cooperative work. It includes theoretical and empirical studies.

Assessment

The productivity of the group is solid. From 2006 to 2010 the group members published 16 conference papers, 8 journal articles, 6 book chapters and 2 books. Historically, the group has been successful in obtaining external funding, in particular from the EU, but the current funds are decreasing. Some of their projects are also affiliated with the center InterMedia. The group reported that it has limited resources to develop software. From 2008 to 2010, 3 PhD and 15 Master's students graduated in the group. The team collaborates extensively with numerous local, national and international partners. Some group members are internationally renowned and, for instance, serve on journal editorial boards.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- The group must stabilize and increase its external funding.
- To increase collaborations in the area of software development, a very competent partner would be the Programming Technology Group in the Department of Informatics.
- The group may want to reconsider its scientific orientation, placing more emphasis on HCI and quantitative studies.

Logic, information and interaction research group

The group was established in 2010 and consists of 2 professors, 1 associate professor and 3 PhD students. It investigates fundamental principles for representing and reasoning about knowledge and information. The group emphasizes foundational and theoretical work, using in particular logic and formal languages. A specific research focus is on scientific problems arising in multi-agent systems.

Assessment

The research agenda of the group is very interesting and challenging, having a strong methodological focus. Recently, two group members experienced a high administrative load, serving as head and teaching head of the department, respectively. Therefore, the past research productivity of the individual scientists is not uniform. The overall performance is good. Some group members have been very active, publishing a large number of papers in high quality journals and conferences. According to the CVs submitted, 15 journal articles and 37 conference papers appeared from 2006 to 2010. Moreover, 1 PhD student and 9 Master's students graduated in the reporting period. The group members have a strong network of international collaborations and frequently serve on the program committees of international conferences.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- With a lot of potential, the group should be allowed to grow and mature over the next years.
- The group should seek to increase synergies among the group members.
- It should place more emphasis on external grants supporting its research.

Social and semantic information system group

The group is the largest one in the department and comprises 2 professors, 3 associate professors and 7 PhD students. Its thematic research focus is on information systems that are based on social and semantic technologies. The investigations include theoretical studies as well as the design and evaluation of systems and technologies. The group members have collaborated for a long time and form a cohesive unit.

Assessment

The group has strengthened since the last evaluation and exhibits a good to very good performance. The publication rate has doubled. From 2006 to 2010, group members have published 14 journal articles, 65 conference papers and 10 book chapters. Furthermore, the team has been successful in obtaining external funding, mostly from the RCN and regional sources. It also participates in a number of EU projects. From 2008 to 2010 the group graduated 4 PhD and 33 Master's students, which is a good result. The group members have a strong international profile. They are frequently invited to join conference program committees and also serve on journal editorial boards. More generally, they maintain an extensive network of scientific partners on the national and international level.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- Although the overall publication rate is good, the group could still improve the number of journal publications.

- Given the competence and experience of the team members, the group should take leadership and seek to acquire a larger grant that is coordinated by the group.

6.3 Gjøvik University College (UiG)

The Faculty of Computer Science and Media Technology (IMT) is focused around computer science, network communication, and media technology. The faculty is divided into two sections of approximately equal size, the Information Security Laboratory ("NISlab") and the Media Technology Laboratory ("MTL"). The latter is less focused on computer science. Within a number of research groups, the faculty formally recognizes three of them as focus laboratories. Two of them, the Norwegian Biometrics Laboratory and the Testimon Digital Forensics Laboratory are a major part of NISlab, whereas the Norwegian Color Research Laboratory ("Colorlab") is a smaller part of MTL.

The NISlab was established in 2001 following a demand from industry and government for the establishment of an advanced degree program in information security. The M.Sc. program was accredited in 2004. The establishment of an Ph.D. program in Information Security (accredited in 2008) is a result of a correct strategic plan to support the development of this area. PhD students graduating from Gjøvik in Information Security are now a fact.

The Colorlab conducts research in image processing, video processing, vision science, graphics, signal processing, physics, image retrieval and computational color. Since 2001 the lab has expanded its activities to become central to the M.Sc. students, in particular the Erasmus Mundus program Colour in Informatics and Media Technology, CIMET. As Colorlab is hosting a number of doctoral students that are not supported by the PhD program in Information Security managed by NISlab, a general PhD-program in Computer Science is under establishment.

The total academic staff consists of 6 professors, 8 associate professors, 6 adjunct positions (professors and associate professors), 2 postdoctoral positions and about 20-25 PhD students. The research activities are mainly funded by university funds. External funding is about 15% the last three years in the given documentation, but was claimed to be much larger during the interviews. The external funding has increased during the last years and it looks promising for the future development. The publications statistics is at most at an average level. The total number of publications per full time equivalent is slightly below average in Norway. The most frequently used journals for publishing are not highly ranked.

Assessment

The NISlab has managed to establish itself as a national resource in information security. It presents strong links to governments and defense organizations, including collaboration on several projects. It also has an extensive research network, including some of the major international players in this area. The research in data forensics is quite unique in Scandinavia. All together, the NISlab is one of the larger research groups in information security in Scandinavia and this has put Gjøvik on the map of information security. Still, some increased excellence in the research outcome is missing.

The Colorlab reports solid research activities, with a strong track record of national and international collaboration. The group has chaired two RCN projects and been a partner in many more national projects.

***Overall grade*: 3-4**

Recommendations
The committee offers the following recommendations

- The external funding needs to be kept at a high level and we believe that the competence is available to achieve it. Both RCN projects and large scale EU projects should be considered. Some steps in this direction may already have been taken, as several EU projects were mentioned in the presentation but not accounted for in the self-evaluation. Achieving a level of 30-50% external funding is a realistic goal.

- Care should be taken if establishing a PhD program in general computer science, not to lose focus in the selected areas. If university funding to focus areas is decreased to support new areas, there is a risk that the faculty will develop into a small computer science department and lose its visibility and impact.

- The research groups needs to increase the number of publications per person, publish more journal articles, and seek publication in better journals. Without a significant improvement it is hard to see that the ICT part of the faculty can be ranked any higher in the future.

6.4 Norwegian University of Science and Technology (NTNU)

6.4.1. Department of Computer and Information Science (IDI)

The Department of Computer and Information Science (IDI) is one of six departments in the Faculty of Information Technology, Mathematics and Electrical Engineering (IME) at the Norwegian University of Science and Technology (NTNU) in Trondheim. The Department has an Advisory Board (including elected and external representatives, typically from relevant industry), management groups and dedicated committees for education, PhD studies, and lab/equipment, to whom the Department Head delegates some decisions. The Department is organized into 6 research groups. This organization is quite recent (initiated in 2010 and carried out early 2011), in order to get a stronger focus on research while avoiding too small research units. The new research groups are: 1) Algorithms, HPC and Graphics (AHG), 2) Computer Architecture and Design (CARD), 3) Data and Information Management (DIF), 4) Information Systems (IS), 5) Intelligent Systems (AI), 6) Software Engineering (SE). The Department's strategic decisions about education and research are formulated in a plan with an associated staffing plan for the next 8 to 10 years. The main strategic decision of the Department leadership lies in the prioritization of new professorships and the allocation of funds (such as positions of PhD students/postdoctoral researcher). The Department has incentives to promote excellent research, e.g. give extra research funds for papers in peer-reviewed journals.

Assessment

The Department has a broad coverage of computer and information science, and is one of the largest departments in this area in Norway (it is the largest IT department in terms of ECTS production, and the second largest in terms of staff after IFI at the University of Oslo). Consequently, it has many alumni in high-profile industries, offering many good connections and opportunities for research collaborations. The strong research orientation of the Department is reflected in a high publication output. The amount of publication points has doubled over the past five years. For example, an average of 3.3 publication points per faculty member/postdoctoral researchers has been achieved in 2010. Few publications are in top journals though. Historically a larger share of publications have been in conferences, but during the last 3-4 years the department seem to have a deliberate policy to publish more in journals, resulting in increasing (yet in absolute numbers still low) journal output. The strong collaboration with industry and participation in innovation projects is also positive. The research has also resulted in a good number of spinoffs (6 in 15 years).

NTNU/IDI is the ICT department with the highest admission requirements in Norway. In 2011 the admission threshold was 50.1 points for the Master in Computer Science, guaranteeing a high level of entering students. The number of students applying for the 5-year master seems to be increasing, while the overall output is around 100 Masters per year. There is however a large dropout rate of about 40% of students mainly in the first two years, many of whom go to other departments. The limited amount of internal funds, which are mainly dependent on the number of course credits produced and, hence, negatively affected by the dropouts, is a big concern as it jeopardizes strategic investments. External funds (e.g. EU or Norwegian Research Council) seem to be difficult to obtain to address this concern. The teaching load, an average of 2 courses per year was reported, can be alleviated

by reduction and streamlining of the (currently too large) course portfolio. Many faculty members seem to take advantage of the generous sabbatical program to take a sabbatical every fifth year (half the scientific staff has had stays abroad in the period 2006-2010), which allows the faculty members to get new scientific impulses and to establish a bigger international network. Recent professor positions appear to have a large number of applications and it is positive that recent senior hires have been international. Overall 22.7% of faculty members are foreign (28% if adjunct positions are included). The large number of retirements in the coming years (1-3 retirements each year from 2010 onwards for the next 8 years) offers the opportunity to the Department for a more strategic approach concerning prioritization of research areas. Women are, however, underrepresented in senior positions (e.g. only 14% of tenured faculty staff are women – 29% in the adjunct faculty staff).

While the Research Council is the main funding source, 75% of the PhD students granted from the Council have been on projects involving industry partners. Yet, the Department should be more active in obtaining research funding from other sources such as EU funding.

There is an increasing difficulty to recruit Norwegians as PhD students, resulting in an increasing ratio of foreign PhD students. Currently, 2/3 of the resident PhD students are foreign and 1/3 Norwegian, but in 2011 all admitted PhD students were non-Norwegian. This poses some problems, as foreign students with limited language capabilities in Norwegian are sometimes difficult to use for teaching assistance, or in some research projects that require case studies in Norwegian industry or public organizations. The situation has improved over the past 5 years, but there still is a large dropout of about 20% in the PhD program, mainly through attrition to industry.

The Department has developed a good strategic plan, aiming to provide high-quality research-based teaching in the core computing disciplines that candidates need for their careers in Norwegian industry or the public sector. The Department is determined to have research strengths in the areas covered by all 6 research groups: algorithms, computer architecture and design, database systems and information management, information systems, intelligent systems, and software engineering. In addition, the Department has identified a list of prioritized research topics on the department level: 1) search and information mining, 2) embedded systems, 3) healthcare and medical informatics, 4) digital ecosystems. At the same time, the Department has a more general strategy to promote scientific excellence, whether it emerges in one of the prioritized areas or in another area. Additionally, although the publication output is high, the Department aims to shift it more towards top conferences and journals. Finally, the Department aims to focus on attracting external funding, facing a future where more of our external funding will gradually have to come from the EU rather than from the Norwegian Research Council.

The Department has responded well to the previous evaluation 10 years ago, by reorganizing the department, by raising the ambition level in professor position announcement though falling short of a tenure-track system with result-based assessment, by streamlining the PhD education through the introduction of a midterm evaluation, by incentivizing publication output and quality, and by focusing more on strategic goals like increased research output and external funding. The drop in enrollment into the computer science program observed over 10 years time is a concern even though enrolment has been stable with increasing number of applications over the past 5 years.

Recommendations

The Department must broaden the research funding portfolio by obtaining more substantial EU funding and by leveraging the industrial contacts. The Department must incentivize the professors more and provide them support to achieve this goal. Though the publication output has increased, the quality of publications, i.e. publishing in higher-ranked journals or in top conferences if that is more applicable to the field, must be increased and incentivized. Also, the large dropout problem in the computer science program (where many students are lost to other programs) must be addressed, investigating scenarios such as over-admitting the number of students or restructuring the curriculum among others. Even after the current reorganization in the Department, initiatives must be continued to further build groups and seek increased collaboration between and within groups, to avoid individual isolation. The Department needs to take advantage of the large number of upcoming retirements, which allows for the hiring of top (international) professors, to enforce stronger and more focused groups while strategically investing in prioritized research areas. The area of computational algorithms for instance should be strengthened. The broad course portfolio offered by the Department's faculty should be rationalized to further increase research time. Actions, such as a PhD mentoring program, must be implemented, to increase the PhD success rate and to reduce PhD dropout.

Algorithms, HPC and graphics (AHG)

Assessment

The group has 5 professors, 1 adjunct professor and 1 postdoctoral researcher. Its research activities are centered on algorithms and focus on a wide range of areas from information access, data search technology, bioinformatics, and graphics to parallel computing. Over the past 5 years the group has supervised 1 postdoctoral researcher and has only graduated 3 PhD students. Currently there are 14 PhD students (8 registered at the department, 6 others supervised but registered at other departments). The group will see two more retirements in the coming years. The group is loosely structured in three pillars with limited synergy across the pillars, and may be sub-critical in certain areas. The group is popular among students and is teaching a broad range of courses. There is large emphasis on dissemination, e.g. the creation of educational movies. The group has a reasonable record of publications, with a good fraction in high-impact journals, though not equally in all areas. There is a culture of innovation with many patent applications and three recent spinoffs and good collaboration with industry. The group is involved in the Microsoft-led CoE Information Access Disruption and several NRC projects; there is, however, no EU funding.

Grade : 3-4

Recommendations

The committee offers the following recommendations

- The AHG group must strengthen the synergy between its different research activities across the pillars. The group should reestablish a better balance between focus and breadth, i.e. deepen the research in selected focus areas while perhaps reducing the wide range of areas covered both in research and course portfolio offered. This should also solve the tension between broad teaching requirements and focused research. The upcoming retirements provide ample opportunities for this.

- A name change for the AHG group should reflect the increased synergy and core activity.

- The algorithm expertise and the emergence of large data banks should provide many opportunities for more research and collaborative activities with academic partners and industry.

- External research funding and in particular funding from EU must increase.

Computer architecture and design (CARD)

Assessment

The CARD group has 4 professors and 1 lecturer. The research focuses on parallel computer architectures, covering both industrially relevant architectures and unconventional beyond-von-Neumann computer architectures. The research spans across hardware to models and software. The group runs a fully equipped hardware lab to be able to implement hardware experimental platforms. It has no postdoctoral researchers presently. The group has a fair publication output over the past 5 years, albeit with few journal papers. Several publications have very few citations. 6 PhDs have graduated over this period. The group has a good interaction with the local hardware industry, and a good collaboration with other institutes in Norway as well as in Europe (e.g. through the HiPEAC2 network of excellence), but has a limited network in the US.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- The international network needs to be improved.
- The group must improve its research strategy and research focus, including addressing emerging opportunities such as energy-efficient computing.
- Collaboration with the algorithms group should be established.
- Postdoctoral researchers should be hired with the requirement to supervise master students, reducing the load for faculty members.
- The group must target more journal publications in top-ranked journals.
- The strong industry connections must be maintained, both nationally and internationally.

Data and information management (DIF)

Assessment

The group has 10 professors, 2 adjunct professors and 2 postdoctoral researchers. The main research topics cover various aspects of management and retrieval of data and information, including data mining. The group has a good and high-quality publication output, albeit sometimes with low citation numbers. The group has a good level of recognition within Europe in the area of database management and in the digital library domain, although lesser yet in the area of information retrieval. The group has a long tradition in working with industry-relevant problems and has collaboration with some local industry (e.g. Microsoft and Oracle) and other national and international institutes. An example is the Microsoft-led CoE Information Access Disruptions (iAD), besides several other national projects. 3 PhDs are partially funded by industry. The group has a good research output in terms of graduated PhD students and spinoff companies resulting from the research.

Grade: 3

Recommendations

The committee offers the following recommendations

- The problem of the loss of faculty members to “administrative jobs” in the university is a concern although it is understood that the group currently only delivers the dean of engineering education at NTNU, while two other positions have finished their term.

- The international visibility of the group should be further increased.

- The synergy among the group members must be strengthened.

- The upcoming faculty retirements provide an opportunity to recruit top-notch (international) professors and to leverage the research focus strategy and the group synergy.

- The balance between service and core research must be well considered.

- The collaboration with relevant institutions and companies should be further increased, and the amount of EU funding must be increased and incentivized by the Department.

Information systems (IS)

Assessment

The group has 9 professors, 2 adjunct professors and 2.5 postdoctoral researchers, showing a good age profile. Several faculty members of the group however serve at higher levels in the Department and Faculty. The group educates 23% of all MSc students of the Department. The group has a broad range of application-oriented research activities: focused on the application of modeling techniques, as well as the development of information systems, with a clear focus on ICT technology in practical use to the benefit of the users. As such, the group has a less technical profile than other groups. The group has extensive external funding, mainly from the NRC, other Nordic sources (e.g. health programs) as well as directly from industry. Over the past decade 18 PhDs have been graduated; currently the group has 19 PhD candidates. The publication output also has tripled over the past ten years, with many journal publications, though not always in top journals. The IS group is strongly involved in the interdisciplinary national research centre on health informatics (NSEP), including a fully equipped usability lab managed by the group. The collaboration with SINTEF is a good opportunity and works well with part-time professor positions. The group's research also has resulted in two spinoff companies over the past decade.

Grade: 4

Recommendations

The committee offers the following recommendations

- After the recent reorganization and considering the broad range of activities, the group must further focus the activities and develop synergies within the group.

- Even though the publication output has increased, the group must further increase the publication quality by publishing more in the top-ranked journals.

- The international collaboration with other researchers and companies must further be strengthened, as it serves as a basis for joint research proposals. This should result in obtaining more EU funding.

- The throughput of PhD graduates must be increased to the level of the other groups, and efforts must be done to recruit Norwegian PhD students for fieldwork and public sector projects that require Norwegian speakers.

Intelligent systems (AI)

Assessment

The group has 10 professors and 2 part-time adjunct professors, and currently has 18 PhD students but with a slow decline. It is the largest AI group in Norway. The Master in Artificial Intelligence seems to draw an increasing number of students. The research covers a very broad range of the AI field, with on one hand research related to computational methods for the modeling and implementation of systems that possess intelligent behavior, and on the other hand the development of techniques and tools for building computer systems that behave in an intelligent way (e.g. biologically inspired systems). Focus areas include applications such as language technology, support systems, smart grids and robotics. Besides basic research the research profile also involves more applied research and strong industry collaborations, for example in the areas of language technology and case-based reasoning. Community involvement is a strong asset. The wide range of activities makes the research impact borderline subcritical in some areas. The group has obtained some European research projects in recent years. The research has resulted in two spin-off companies, but also in the development of methods and tools with direct benefits for society. The group takes part in the core activity of the NTNU's SmartGrid team as well as the National Smart Grid initiative, which are highly interdisciplinary and international research areas. Contacts have been established with other groups nationally and internationally to cover the interdisciplinary research. The group has a good publication output in journals and mainly conferences, though not always in the top journals.

Grade : 3-4

Recommendations

The committee offers the following recommendations

- Collaboration and synergy within the group must be improved.
- The international networking must be further strengthened.
- Actions must be taken to improve the success rate of EU project applications, to expand the EU funding.
- The quantity and quality of the output in journal publications, i.e. publishing more and in top journals, must be increased, in an even manner for all faculty members.
- The throughput of PhD students must be secured.
- The group could also benefit from using more postdoctoral researchers.
- The transition to new leadership replacing the upcoming faculty retirements provides substantial opportunities to establish strategic goals; a longer-term strategic plan must be developed to this end. For example, the group could consider connections to the bioinformatics field.

Software engineering (SE)

Assessment

The group has 6 professors, 4 adjunct professors (three of SINTEF) and 3 postdoctoral researchers, with 6 out of 13 being women and 4 out of 13 being foreign. Three of the 6 professors will retire in the next 2-5 years, and in parallel the group hopes to further grow the number of professors in the coming years. There is a good collaboration with SINTEF. The group draws a large number of MSc and PhD students. Over the past 10 years 22 PhDs have been graduated, and today the group has 20 PhD candidates (of which 70% are foreign). The research focuses on applied, empirical software engineering, i.e. the development and maintenance of large and complex software systems following the empirical paradigm, and is carried out in close collaboration with the Norwegian ICT industry and the ICT users. The three main research themes are: software quality and development process, including issues such as safety and reliability, novel software technologies and user experience, including in emerging areas like software and art, computer games, ICT and learning. The group has been very successful in getting external funding, both national and international. The research has resulted in many practical outcomes such as new development platforms and methods, as well as in many publications Many of these are in journals but even many more in conferences, as is typical for the field, and with an increasing number in top journals. The group also has a strong dissemination effort to society. Besides many national projects involving other Norwegian academic and industrial institutions, e.g. the Norwegian network of game developers and game researchers, the group also has good international contacts and projects, resulting in 25% of the papers having foreign co-authors.

Grade : 4

Recommendations

The committee offers the following recommendations

- The group must carefully (re)consider the balance between core basic research and applied research, and consider spinoff's for too service-oriented activities.

- The connections at the national level to Simula Research Laboratory and to the University of Oslo should be increased.

- The group must take urgent care of the new leadership, i.e. the replacement of the three upcoming retirements with high-ranked (national or international) professors.

- The group should also increase publishing in stronger journals.

6.4.2 Department of Electronics and Telecommunication (IET)

The history of the department reaches back to the foundation of NTNU and today it consists of 6 research groups with a total of 33 permanent staff members and graduation of 10-15 PhD's on a yearly basis. However, in 2004, the department was reorganized into today's structure, partially following the recommendation of the past evaluation. It has a strong tradition for a close collaboration with SINTEF and this continues to be active.

The department members have a moderate teaching load and sabbatical leaves have been implemented in the department.

The department is home to a substantial collection of experimental facilities, many of which are unique to Norwegian research. Sustainability, support and renewal of these remains a challenge for the department. However, it is these facilities that makes the department unique and offers a broad range of activities, from materials to devices.

The department is responsible for several MSc programs already and several are being discussed to secure increased supply of qualified students

Assessment

The reorganization, following the last evaluation, appear to have been a success and lead to increased synergy and increased research output as measured in high quality publications. The external funding rate has been about constant. However, pending retirements of several key staff members represents a challenge that should be carefully planned for. The evaluation committee commends the department for viewing this situation as an opportunity to reshape the research activities and focus of the department and to evaluate staff levels.

The strong outward look in recruitment of both faculty and PhD students is encouraging and should be continued.

The department reports serious problems with retaining students. The committee strongly encourages the department to make a study of what is the cause of this and attempt to change the educational structure to identify clear entry for student to enter the programs at different stages to balance this loss of students. Furthermore, if this is a general problem, options for early over-admission could be considered.

The strong but overall slowly declining collaborations with national research institutes should be addressed, possibly with Professor II positions when appropriate and a continue emphasis on the development of projects and proposals. This may also be a way to increase EU funded projects, which is otherwise low.

Recommendations

The department has substantial strength but is also faced with a number of challenges that need careful considerations. On the faculty level, a number of pending retirements offers some substantial challenges for maintaining expertise but also provides opportunities to develop and strengthen emerging areas and build new areas of expertise. This should be planned carefully, including a redistribution of resources within the department to support unique facilities of national interest.

The ongoing operational cost of substantial experimental facilities causes substantial challenges and needs to be addressed to sustain activities. The cost of some of these facilities has to be supported as national facilities, either through internal reprioritizing or through increased external funding, for instance through EU based collaborative awards.

The substantial loss of students may partially be offset by the development of clear entry points to the different research groups as well as a deliberate over-admission of students.

Acoustics (AK)

The acoustics group, comprising four staff members and two professor II's, is a unique national resource and the only group with substantial expertise in this area. It is clearly an area of national interest with activities in underwater acoustics and hearing and transducer development. While the emphasis maintains an experimentally focus, there is an increasingly strong emphasis on computational modeling. It is also a relatively small group with 4 faculty members but it has strong collaborations with SINTEF. Its experimental facilities are unique but they also present a substantial financial burden.

Assessment

During the last period, there has been an emphasis on high level publications and international visibility and this has largely been successful. The small group makes it vulnerable to staff changes and retirements and there are challenges with recruiting and retaining students. Furthermore, apart from SINTEF, the external collaboration with industry is limited. Reviving the declining PhD and MSc programs should be considered a priority. The establishment of an MSc program as an entry point may be an option for growth but should be carefully evaluated for its impact on resources.

Grade: 3

Recommendations

The committee offers the following recommendations

- Maintain and strengthen connection to SINTEF, possibly in the area of environmental noise.
- Plan for end of Center of Excellent award and alternative funding sources.
- Continue the strengthening of computational activities to fully complement experimental activities.
- Increase visibility, nationally and internationally, and continue to improve publication quality.

Signal processing (SI)

This is the largest group in the department with 9 permanent staff members and a healthy production of MSc and PhD candidates. A research focus of the majority of the group is digital communication, mainly wireless communications and sensor networks and a second focus on speech, image, and multimedia processing. It is a reasonable large group and a stated goal to be a national leader. The group is highly collaborative and well funded but also strongly dependent on external funding of its main activities. It is generally a strong and stable group with a well-developed international network.

Assessment

Since the last evaluation, substantial focus has been on an increase in publication rate and quality. This has been successful and has helped ensure strong funding. While there is an increase in PhD students the group may be a underutilized resource given the size of the group. The idea of micro sabbaticals is interesting and should be evaluated carefully. With technology changing rapidly, it is essential that the group adapt its research activities to new ideas and opportunities beyond the traditional scope of the group.

Grade: 4-5

Recommendations

The committee offers the following recommendations

- Continue to grow the PhD program
- Seek to expand research activities beyond traditional scope.

Radio systems (RA)

This is a small group, focusing generally on communication, navigation, microwave engineering, and remote sensing. It seeks to cover radio science as a national competence. The group is home to experimental facilities, unique in Norway but expensive to maintain and operate and the group maintains core national expertise in antenna and microwave technology.

Assessment

The small size of the group presents substantial challenges and causes concern for the sustainability of the group. This is further emphasized by the average production of publications and the limited interactions and collaborations within the group. The high cost of the experimental facilities suggests a need for increased national collaborations and a stronger emphasis on ways to fund PhD students to ensure active use of unique facilities. The declining PhD and MSc graduates should be addressed to ensure sustainability. Given the small size of the existing group, the model of further reducing this size to recover funds to support experimental facilities is risky and may render the group subcritical.

Grade: 3

Recommendations

The committee offers the following recommendations

- Increase synergy and collaborations within the group
- Seek sustainable funding for unique experimental facilities, possibly by closer collaborations within and beyond NTNU
- Increase external funding to further offset this cost.

Circuits and systems design (KS)

This is a popular group among industry with a broad focus on embedded systems, analog system design and advanced testing facilities. With 7 permanent staff members is also one of the larger groups in the department. An MSc program is being discussed as a way to increase attraction of international students and lift visibility nationally.

Assessment

The involvement of school children to generate interest is commendable and should be considered more generally, possibly even as national model. A reported lack of student interest is not reflected in the number of PhD and MSc students, both of which are substantial and the MSc program is the largest in the department by quite some margin. The group has historically had a strong connection to national industry and it is clearly essential that this be maintained for a research area such as this. The efforts to increase external funding should be commended.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- Continue to build and strengthen connections to industry
- Increase visibility through collaborations and increased quality of journal publications.
- Continue to grow external funding.

Electronic devices and materials (KT)

The group, comprising of four permanent staff and one Professor II, focuses it research on nano-materials and quantum systems with a heavy experimental focus. There is a strong emphasis on high-quality publications, enabled through strong experimental facilities and an international outlook and network. The group is a major driver in the university wide initiative to develop a state-of-the-art clean room, serving as a national facility. Recruitment is less of a concern in this group, possibly due to public awareness of nano-science, although some lingering concerns about general quality of students was voiced.

Assessment

The emphasis on publications has been successful and has provided a high degree of visibility and a substantial impact of the work. The number of students, both PhD and MSc students, is reasonable, if perhaps low on an international scale, for a group of this size while collaborations with industry appears to be less well developed and should be strengthened. The group continues to seek a way to pay for large collaborative facilities through collaborative agreements - and have expressed some initial ideas that could be considered as possible models for other groups. The rapidly changing research areas will continue to pose challenges and require the group to revisit its priorities and resource allocations at regular intervals.

Grade: 4-5

Recommendations

The committee offers the following recommendations

- The group is encouraged continue explore and plan to seek to identify emerging areas in a rapidly changing field.
- Increase national collaborations, including with industrial partners.
- Pursue the development of new funding models for experimental facilities, including collaborative models.

Electro-optics (EO)

The group has a staff of four with one additional professor II and with a strong research focus on biomedical optics and nano-photonics, strengthened through close connections and collaborations with hospitals. The research profile is further strengthened through industrial connections and international collaborations. Some problems with recruitment of students, in particular at early stage of studies, are reported. The group is also facing problems with covering cost of experimental facilities, much like that of other groups.

Assessment

The group has leading national competence in optics and photonics and has a solid publication record. Group members have complementary expertise but the group needs to expand through an increased number of postdoctoral researchers. The number of local PhD students is on the lower end, but this is complemented by a substantial number of MSc students and a few PhD students being substantially advised by staff even if the students are registered at a different institution. Initial efforts to attract EU funding have been successful but more is needed, by emphasizing quality over quantity.

Grade: 4-5

Recommendations

The committee offers the following recommendations

- Continue development of strong EU proposals.
- Continue to grow and strengthen national collaborations
- Pursue the development of new funding models for experimental facilities, including collaborative models.

6.4.3 Department of Telematics

The Department of Telematics at the Norwegian University of Science and Technology is a rather small department and consists of three research groups. The total academic staff financed by the university is 13 professors, 2 associate professors, 2 adjunct professors, 3 adjunct associate professors, 2 adjunct assistant professors, 3 postdoctoral researchers, 12 PhD students and technical and administrative staff. In addition to this, there are 1 researcher, 1 professor, 1 adjunct associate professor, 6 postdoctoral researchers, and 23 PhD students financed by external grants.

The department is responsible for

- A five year MSc program in Communication Technology
- A two year International MSc program in Telematics
- A two year MSc program in Security and Mobile Computing (Erasmus Mundus)

During 2008–2010, 15 PhD and 163 MSc degrees were completed.

Research is done in communication networks and services in a wide sense with a strong applied component. The department has close links to Q2S - the Centre for Quantifiable Quality of Service in Communication Systems, which is a Norwegian Centre of Excellence at NTNU.

Recommendations

The conclusions from the 2002 review was that the department was a success from an educational point of view, but weaker from a research perspective. This was mainly due to a low publication rate. The total number of publications has improved but the number of journal papers per faculty is still low and the citations are below average in its field. The main recommendation is to incentivize further increases in quantity and quality of journal papers.

The focus of the research is quite diverse, and the ending of Q2S in 2012 could create financial difficulties. We see potentials for increasing interaction with Department of Computer and Information Science and Department of Cybernetics. The areas of computing, communication and control are converging and networked systems are important from a broad engineering perspective ranging from wireless automation to social networks.

Networks group

The research group has 5 professors, 2 associate professors, 2 adjunct professors, 1 adjunct associate professor, 1 externally financed adjunct associate professor, 2 adjunct assistant professors, 2 postdoctoral researchers, 3 externally financed post-docs, 5 internal PhD students and 14 externally financed PhD students.

The research is focused on modeling and evaluation of quality of service of communication networks. The project portfolio seems broad and a somewhat reactive rather than proactive nature.

This is by far the strongest group within the department with a broad project portfolio. The group is rather heterogeneous and there is a need to rethink the focus of the research. The total number of publications per number of man-years is 4.8 compared to 3.5 for the total department. The group has published 36 journal articles out of 55 for the department but the articles has rather low citations statistics.

There is a need for more international visibility and the closing of Q2S may create problems. The ideas for follow-up proposals seem is a challenge since the industry within the area of classical communications networks has left Norway. Instead there should be possibilities in industrial applications such as machine to machine communication and cloud computing.

***Overall grade*: 4**

Recommendations

The committee offers the following recommendations

- Topics such as networking in the context of cloud computing and data centers have some potential for the group to help offset funding challenges after Q2S.
- Expanded collaboration with Simula Research Laboratory is encouraged.
- There is a need to improve the numbers of high quality papers.
- The EU focus in funding options could be increased.

Networked systems group

The group has 5 professors, 1 external professor, 1 adjunct associate professor, 3 external postdoctoral researchers, 4 internal PhD students and 3 external PhD students.

The research is on architecture and engineering of networked systems with a applied focus on applications.

The total number of publications per number of man-years is 2.2 compared to 3.5 for the total department. The group has published 6 journal articles out of 55 for the department. Most of the work is reported in conference proceedings.

***Overall grade*: 2**

Recommendations

The committee offers the following recommendations

- There is a strong need to improve the numbers of high quality papers.

- The committee feels that the research is too inward looking. The group claims that there is a need for more capacity on practical implementations. We instead recommend that the Networked Systems Group should join forces with the Network Group to increase its theoretical competence. Since the telecommunication sector is decreasing in Norway, the recommendation is to move into new application areas such as smart power grids.

Information security group

The group has 3 professors, 1 adjunct associate professor, 1 postdoctoral researcher, 3 internal PhD students and 6 external PhD students

The research is focused on cryptology, communication security, access control and digital forensics. The group is heading FRISC - a national research council networks of information security.

The total number of publications per number of man-years is 4.5, compared to 3.5 for the total department. The group has published 17 journal articles out of 55 for the department. Much of the work is only reported in conference proceedings.

***Overall grade*: 2-3**

Recommendations

The committee offers the following recommendations

- There is a need to further improve the numbers of high quality papers.
- The area of ICT security is very relevant and there should be plenty of opportunities to pursue funding opportunities. The FRISC platform should be a perfect base for national collaborative projects.

6.4.4 Department of Engineering Cybernetics

The Department of Engineering Cybernetics at the Norwegian University of Science and Technology is a rather small department and consists of two research groups. The total academic staff financed by the university is 10 professors, 4 associate professors, 3 adjunct professors, 1 researcher, 3 adjunct associate professors, 3 postdoctoral researcher, 9 PhD students and 12 technical and administrative staff. In addition there are 2 adjunct professor, 2 adjunct associate professors, 2 postdoctoral researchers, and 28 PhD students financed by external grants.

The department is responsible for

- A five year MSc program in Engineering Cybernetics

During 2008–2010, 30 PhD and 199 MSc degrees were completed.

Recommendations

The committee offers the following recommendations

The conclusion from the 2002 review was that the department was very strong in two closely related areas, which now has been merged into the control systems group. This has creating an even stronger world leading research constellation. This also makes the weakness of the Industrial Computer and Instrumentation Group more apparent. Our strong recommendation is to maintain the department to ensure strength in research and education. We also encourage the carefully selected balance between research and education.

Control systems group

The total academic staff financed by the university is 9 professors, 2 adjunct professors, 1 researcher, 1 adjunct associate professor, 3 postdoctoral researchers and 6 PhD students. In addition there are 2 adjunct professors, 1 adjunct associate professor, 1 postdoctoral researcher and 22 PhD students financed by external grants.

The theoretical research is focused on optimization based control and estimation, including modeling and identification, model predictive control, nonlinear control and adaptive control. The applications are in robotics, navigation, marine craft, unmanned vehicles, oil and gas production, new energy systems and process control.

The total number of publications per number of man-years is 7.6 compared to 5.5 for the total department. The group has published 127 journal articles in the period 2006-2010. This is excellent from an international perspective.

***Overall grade*: 5**

Recommendations

The committee offers the following recommendations

- Stay focused on the theoretical foundation of control and at the same time apply these results to well chosen exciting applications with close contacts with local industrial collaboration and SINTEF.

- Focus on process and energy related to local industry, but rethink focus on service robotics, which seems less connected to industrial applications.

- There are also very good opportunities to inter-disciplinary research projects with other research groups in computing and communications. For example cyber-physical systems is a recent research field with a lot of EU collaborative opportunities.

- It was noted that this research group has a good balance between teaching load and time for research. It was also noted that the group has free capacity to supervise more PhD students.

Industrial computer and instrumentation systems group

The total academic staff financed by the university is 1 professor, 4 associate professors, 1 adjunct professor, 1 adjunct associate professor and 3 PhD students. In addition there are 1 adjunct associate professor, 1 postdoctoral researcher and 6 PhD students financed by external grants.

The total number of publications per number of man-years is 1.9 compared to 5.5 for the total department. The group has published 22 journal articles in the period 2006-2010.

***Overall grade*: 3**

Recommendations

The committee offers the following recommendations

- Continue the direction of research, but broaden application domain to expand collaboration.
- Carefully evaluate the a difficult task of balancing service to local industry with core research.
- There is a lot of promising research directions within this field, for example wireless automation and embedded control system and these opportunities should be carefully evaluated.

6.5 University of Oslo

6.5.1 Department of Informatics

The Department of Informatics is one of nine departments in the Faculty of Mathematics and Natural Sciences at the University of Oslo (UiO). It is the largest and broadest academic ICT department in Norway. It comprises the field of Computer Science including interdisciplinary activities towards mathematics, physics, geo-sciences, life sciences, social sciences, and humanities. The Department has grown steadily over the years to its current size of about 64 faculty members, 21 post-doctoral researchers, 225 Ph.D. students, 450 Master students and more than 1100 Bachelor students. Faculty (1/3 from abroad) and Ph.D. students (50 % foreign) have a strong international background. The Department of Informatics is organized into 13 research groups. Twelve of them are being evaluated in this evaluation – the exception is the Computational Mathematics group. The research groups of the department have very heterogeneous sizes, ranging from 4 to 12 faculty members per group.

Assessment

The department covers a very wide area of research, but tries to establish some focus topics, for example, by building around Centers of Excellence consisting of research groups with complementing research topics. The department head has a good vision considering the building of focus areas and attempting to exploit synergies among research groups. However, synergies are limited, which might be caused by groups being scattered across the campus.

The department has a good number of collaborations, also with industrial partners. Among them are Statoil, Microsoft, and SINTEF. 2-3 spin-off companies have been founded per year. There seems to be limited incentives for researchers to compete for third-party funded projects, in particular on the European level. Nevertheless, more than 20 activities have been started in the 7th framework program.

The number of (indexed) publications has been growing during the recent years, but still has some room for improvement. The department head agrees to target publication of research results in higher quality journals, especially to increase publication metrics.

Teaching load among groups and within groups seems to be balanced. With approx. 2 courses per year per faculty member, the teaching load is low compared to international standards.

University of Oslo has a strong advantage compared to other universities due to being located in the capital and its strong reputation from the past, which lead to rather good positions in international university rankings.

Recommendations

Currently, research groups are rather autonomous with limited collaboration among them. Synergies among the research groups should be exploited in a better way.

Research groups are very heterogeneous in size. It is recommended to have more balanced groups, either by hiring in the small groups or by restructuring. The committee considers three professors as a critical mass for a research group.

There should be stronger incentives for faculty members to seek and participate in third-party research projects.

Although, computer science publications focus very much on conferences and workshops, it is recommended to consider stronger publication activities in journals, particularly the ones in publication indices. A good balance between high-caliber conferences and high-impact journals should be the target.

Despite the large size of the department, several important research topics in computer science are only partially covered by the Department. There are no dedicated research groups on security and machine learning. A few groups address these topics, but it should be considered to have dedicated research groups on these topics.

The number of graduated Ph.D. students is rather low compared to the number of faculty. This ratio should be increased.

The quality of the research groups is rather good overall. However, there are no research groups with outstanding international visibility. 2-3 research groups having a kind of lighthouse character with internationally widely visible leaders should be established in order to increase international visibility of the whole Department.

Certain research groups have strong focus to serve other research activities, even in other departments or disciplines. Those research groups should find a better balance between service and own core research topics.

Biomedical informatics (BMI)

The Biomedical Informatics group was formed in 2001 with the aim of contributing to method development in bioinformatics and statistical genomics. The group is rather small with just four faculty members, which is low compared to its broad service-like activities.

Assessment

The group has a very strong service-orientation, in the sense that the group is supporting biological and medical research groups. Although this is very valuable for those groups, there is a risk that the groups own core research works, e.g., on algorithm development, looses focus.

The group achieved a good number of publications in journals, but mostly in medical and biological journals. The number of Ph.D. students graduating from this group has been modest.

Due to the strong service orientation of the group members, there is a risk of losing coherence and synergy inside the research group.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- The group is mainly recruiting PhD students from biological and medical sector. More recruitment from informatics would maintain and strengthen informatics competences.

- Stronger focus on informatics research and improving synergies and coherence should be sought.

- The number of graduated Ph.D. students should be increased.

Digital signal processing and image analysis (DSB)

The focus of the DSB group is on image analysis and on signal processing for acoustic imaging. The group performs research in medical ultrasound, sonar and seismic, medical texture analysis, and sonar technology.

Assessment

Since 2000, 17 Ph.D. students have been graduated, 10 of them since 2008. The research group has high expertise in both signal processing and image analysis and thus potential for cross-disciplinary research. Several start-up companies resulted from the research group. The research group collaborates with DMMS on smart environments and with defense research (FFI) in remote sensing. These many activities, however, create a risk that DSB provides services to other groups at the expense of own core research. The number of publications and their citations is rather strong compared to other groups of the department. The group had several good industrial collaboration activities, some of them resulting in patents.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- The committee recommends focusing on a certain core of research topics and being selective in service activities with other partners.

Nanoelectronics (Nano)

The Nanoelectronics group (NANO) performs research in the areas of ultra-low-power and low-supply voltage integrated circuits and CMOS systems design. Typical application areas are biomedical engineering and wireless sensor networks.

Assessment

Despite the relation to some other groups of the Department, the research areas are somewhat off topic in the Department. Energy-efficiency and robustness are important issues to be considered. The publication rate in international journals and conferences are very good when compared to the Department. The production rate of graduated Ph.D. student is average with 7 Ph.D. students graduated since 2007. The group is very oriented to real-world engineering, has very strong relations to industry, and depends strongly on appropriate laboratories. Appropriate support for laboratories from the department and/or the university is required for sustainability and maintenance.

Grade: 4

Recommendations

The committee offers the following recommendations

- National visibility of the research group is fairly low and should be improved, in particular to attract good students to maintain the group's current strength.

- The number of publications is high but publications are focusing too much on conferences. More journal publications are recommended.

- The committee also recommends developing a plan for future recruitment of faculty members and students.

Robotics and intelligent systems (ROBIN)

The group was established in 2006. It consists of two faculty members (one more will be hired in 2012), three postdoctoral researchers, and nine PhD students.

Assessment

This is a rather small group compared to others in the department, but it is expected to grow in the near future. The ROBIN group has RCN and EU funded projects for funding post-docs and Ph.D. students. The research areas are fairly inter-disciplinary, in particularly with the music department, and are mainly centered around bio-inspired computation and hardware in robotics and music applications, adaptive systems, and systems for motion analysis. On particularly original area is the application of 3D printing technology. Given the small size of the group, the research areas covered are rather broad.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- Focus the research in a few key areas.
- Increase collaboration with other research groups inside and outside of the department.
- Very strong need to publish more in journals.
- The new position to be filled should be used to strengthen the focus of the research group.

Distributed multimedia systems (DMMS)

The DMMS research group is fairly small. The research strategy is interdisciplinary within Computer Science and deals with topics linked to networking, operating systems, data management, and distributed systems. Research topics, which address several of those issues simultaneously, are investigated. Recently, there was a shift from classical multimedia systems towards cyber-physical systems including collaborations with members from the Nano-electronics research group and the Digital Signal Processing research group. This shift can be justified by the available expertise by the group's faculty members. The research topics addressed are of societal relevance, e.g., in the area of smart environment technologies.

Assessment

Research work is very system-oriented and linked to applications. Visibility on the European level is very high compared to other research groups of the department. Although improved recently, the research group does not fully exploit its potential for high quality publications, in particular in journals.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- Strengthen collaborations with other related research groups, in particular to the Network and distributed Systems group.

- Stronger efforts to publish in indexed journals.

Network and distributed systems (ND)

The research of the ND group is organized into a number of activity areas spanning most layers of networking and distributed systems. The group is very large and spans mainly classical topics in multimedia networking such as robustness, network performance, wireless networks, interconnection networks and end-to-end communication.

Assessment

A strong collaboration with Simula Research Laboratory exists due to the involvement of Simula researchers in the ND group. However, this also means that the research work is performed at two different locations. Research topics are very interesting and relevant for industry. The publication record of the group is good, but considering the large size of the group there is room for improvement.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- Research topics are rather traditional. Certain topics such as cloud computing could be investigated more in the future, possibly at the expense of some topics that has lost relevance.

- Substantial research is very application-oriented and mature. Basic research activities should be strengthened and expanded.

- The number of journal publications should be increased.

Object-orientation, modeling and languages (OMS)

This group's research activities are within the areas of Programming, Algorithms, Modeling and Software Engineering. In particular, new concepts in object-oriented modeling and programming languages are investigated. Tools for these programming paradigms are being developed.

Assessment

Since 2006 OMS faculty has supervised 14 Ph.D. students. Currently most Ph.D. students are funded by the University and SINTEF research projects, enabled by the strong industry relevance of the group's research. Collaborations with Simula Research Laboratory is rather weak. OMS has a decent publication record, although some members do not publish a lot. There is limited internal collaboration, i.e. within the department, although the group is in the core of computer science. Plans for future recruitment are somewhat vague. The group's research focus has been significantly improved since the previous evaluation, but is still somewhat diverse.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- The many retirements in the near future should be seen as an opportunity to redirect research topics, in particular to establish and strengthen collaborations with other research groups of the department.

- Currently, there are no clear plans for how to replace the faculty members to be retired soon. Appropriate plans need to be developed as soon as possible.

- Increased focus on publication quantity and quality.

Precise modeling analysis (PMA)

The focus of the PMA group is on the development of languages and formal methods that can guarantee the quality of software, with emphasis on open distributed systems, and on tool support. The group is developing formal modeling languages and formal analysis, methods and tools to ensure quality of complex and critical software systems with emphasis on distributed systems. The research is organized around a number of overlapping and mutually beneficial activities, all based on the rigorous application of formal methods.

Assessment

The group has very strong European research activities, through EU-funded projects.

Grade: 2-3

Recommendations

The committee offers the following recommendations

- The title of the research group does not sound very attractive to students and should be changed.
- National and international visibility of the group should be further increased.
- Improve the research focus of the group.

Logic and computation (LC)

The activities of the newly established Logic and Computation group include basic research as well as applied research in collaboration with industry and the public sector. The basic research focuses on proof theory, while the applied research is done mainly in the area of semantic technologies applied to real-world applications, especially in the public sector and the oil and gas industry.

Assessment

The research group has a good balance between basic and applied research. However, publication records are weak.

The main weakness is the lack of a solid research group structure. The group is a fairly new collection of different faculty members from different areas with little prior collaboration. Retirements of one of the two professors during the next years will create challenges to maintain a critical size of the group.

Grade: n/a

Recommendations

The committee offers the following recommendations

- The group name should be made more attractive in order to attract students.
- The group should exploit synergies and improve internal collaboration. High-profile publications should be targeted in the future.
- The good balance of theoretical and applied research on real-world problems should be kept.
- The group's potential should be used to strengthen the industrial collaboration.
- The critical size of the group must be ensured.

Language technology (LTG)

The research group on Language Technology founded in 2006 is a new group and performs research on formal models for natural languages, machine learning, and search algorithms.

Assessment

The publication record has improved during recent years, although it is still on a low level. The group achieved some good research results and has a good international network.

Grade: n/a

Recommendations

The committee offers the following recommendations

- The group should significantly increase the number and quality of journal publications.
- There might be some research opportunities in social media.
- The group should seek to maintain focus. International visibility and local collaborations should also be improved by proper exploitation of the group's capabilities.
- The group is very much focused on technologies for the English language. Other languages might create new opportunities.

Design of information systems (Design)

The research group studies the effects of IT design on individuals and the society with the objective of designing socio-technical alternatives. Topics addressed include human computer interfaces and participatory design. The research focuses on qualitative evaluation methods involving users. A strong empirical basis has been established during previous years. The research is therefore of interdisciplinary nature.

Assessment

Overall, the group brings in a social perspective to computer science. The publication record is very poor. Efforts to educate interested students in improving their programming capabilities have been successful.

Grade: 2

Recommendations

The committee offers the following recommendations

- The research group should strengthen existing relations to SINTEF and establish stronger links to other national researchers with complementing expertise, e.g., in human computer interface design (NTNU). Corporations must be carefully selected when services to partners are provided. The group has to focus on basic research.

- The publication record must be significantly improved in order to reach standards within the department.

- The group may focus on selected application areas that are highly relevant for the society, e.g., home care. Diversity in those application areas should be limited.

Global infrastructures (GI)

The research group on Global Infrastructures is a very large group with 7 professors and more than 40 Ph.D. students. During the last five years more than 25 Ph.D. students graduated.

Assessment

The research group is well positioned and investigates the socio-technical complexity of large-scale "information infrastructures", in particular health information systems in developing countries. These systems very much depend on mobile communication and open source systems. The research performed is of a very applied nature with high societal impact.

The publication record is good compared to the department. However, basic research results have been rather weak compared to other groups of the department.

The very strong application-oriented nature of the performed research has the risk of limiting overall research quality. In particular, substantial operational tasks and maintenance of systems may have negative impact on research quality. Similar to the Design group the research is based on empirical work. The research group has been very successful in acquiring third-party funding.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- The operational and software development work performed by the group should be critically revisited. It is questionable whether a university is the right place for software development and operational tasks of the level seen in this group. Outsourcing activities beyond developing prototypes to other organizations should be considered.

- The committee strongly suggests the creation of spin-off companies for any tasks after building first research prototypes. This should be better for maintaining the group's research quality but also the quality of the operational work too. Such a model has to ensure that the software developed by the group will be available as a basis for consecutive research projects.

- Increase emphasis on basis research and continue focus on high-quality publications.

6.6 University of Stavanger

6.6.1 Department of Computer Science and Electrical Engineering (CSEE)

The University of Stavanger was established in 2005 as a continuation of the Stavanger University College. This transition period was accompanied by the introduction of a number of master/PhD programs, an increased research focus while maintaining the same financial model. The department consists of two research groups, the' Computer Science' (CS) group and the 'Signal Processing and Control' (SP&C) group. The CS group works in 6 research areas: distributed event-based system, automatic computing, sensor networks, contextual information handling, dependability and security issues, modeling & simulation. The SP&C group focuses on 4 topics: biomedical, sparse representation of signals, adaptive filter theory with applications to measurement science, biomedical system analysis. The total academic staff is 6 professors, 9 associate professors, 1 adjunct professor, 3 postdoctoral researchers, 11 PhD students and 7 administrative and technical staff. The department has a research/educational infrastructure consistent with its needs.

Assessment

The department is still in its transition period and many staff members' self image primarily is that of the educator rather than of the researcher. As a consequence the quantity and quality of publications is moderate and could be increased. External funding has increased over the reporting period. In particular, the CS group has benefited from NCR and EU funding. The department started hiring postdoctoral researchers in 2006. Whereas such policy is laudable, inbreeding (all postdoctoral researchers are former PhD students) is a poor policy that penalizes both the students and the institution. The department has introduced sabbatical leave; this is a good incentive for faculty to go abroad and leverage their research competencies.

Recommendations

Leveraging the research competencies of the permanent staff is a key challenge for the department and the evaluation committee recommends increasing the focus on research. The research activities are diverse and too many. The staff attitude seems to be very individualistic. The committee encourages the department to increase coherence in activity, increasing ambition, enhancing and strengthening the group structure and putting emphasis on quality over quantity. The level of cooperation with industry is good and the committee recommends maintaining industry connections.

Computer science group

The group is composed of 2 professors, 4 associate professors and 1 adjunct professor, 3 postdoctoral researchers (2 internal and one external) and 6 PhD students. The group performs research in different areas such as distributed event-based system, automatic computing, sensor networks, contextual information handling, dependability and security issues, modeling & simulation.

Assessment

The work of this group seems to be organized around projects of relevance for industry. However, projects address various different topics and the impression is that the research lacks focus. The self-evaluation report does not describe any shared research objectives but instead presents a collection of faculty CVs with individual research topics. The publication record is good but the level and frequency of publications is highly variable from one faculty to another. Apart from that, the bibliometric data show a low rate of citations. The group has international connections but it is difficult to judge their depth. EU funding is non-existent and the NRC funding is declining over the last three years. The group is active in supervising PhD students and attracting postdoctoral researchers.

Grade: 3

Recommendations

The committee offers the following recommendations

- Continuing PhD supervision and involving postdoctoral researchers in research actions.
- Increase research focus and synergies.
- Develop initiatives to increase funding levels.
- Increase the quality of publications.

Signal processing and control group

The group is composed of 4 professors, 5 associate professors and 3 PhD students. Research activities cover a broad range of topics with a focus on biomedical analysis and areas such as adaptive filter theory, pulse-width-modulation for digital audio amplifiers, sparse approximation and dictionary learning, optimized use of simulators, smart capacitance based two-phase sensors and estimation of optical flow with applications.

Assessment

Apart from the biomedical data analysis group, which develops research in a coordinated mode on a well-identified topic, the rest of the group is heterogeneous and the focus of the research is lacking. The overall publication productivity per full time equivalent is 1.0, which is well below the average for all units covered by the evaluation (1.56). However, the citation rate of the publications in journals is high. The SP&CG group has a field normalized citation index of 121, meaning that the articles are cited 21% more than the corresponding world average. This high citation rate is due to publications in biomedical journals. A large part of the research is conducted in projects funded locally. External funding is low and there is no EU funding.

Grade: 3-4

Recommendations

The committee offers the following recommendations

- The group needs to reduce its heterogeneity and increasing focus and rethinking its general research strategy.
- Connections with local industry and public organizations are very good and these should be maintained while developing external funding.
- The number of PhD students is too low and shall increase.
- The group shall seek to hire postdoctoral researchers.

6.7 University of Tromsø

6.7.1 Department of Computer Science

There are currently 4 research groups in the department; 3 groups within different areas of computer systems research, and one group working in medical informatics and telemedicine. There are in total 12 employed professors, one researcher and two postdoctoral researchers. In addition the department has about 10 researchers in professor II positions or similar arrangements.

Assessment

The department has graduated about 2.3 PhDs per year the last three years. The research activities are mainly funded by the university but the external funding is in the range 34-48%, which is a good figure. However, essentially all external funding is grants from the Research Council of Norway. No EU funding has been granted the last three years.
The department demonstrates a lot of collaboration with internationally recognized research groups. The groups appear to be working on relevant and interesting research problems. The number of publications for the department is below average in Norway and also the journals and conferences where publications appear are not highly ranked either.

Recommendations

*T*he department should have a clear plan on how to increase the quantity and quality of publishing papers. Researchers in areas where conference contributions are tradition should be encouraged to write more journal papers. We believe that the research activities are strong enough to support an increase.

The department should put more emphasis on obtaining EU funding.

The university should develop a strategy for the long-term development of computer science, where identified problems like recruitment, career support, level of salaries and gender balance are considered.

High performance distributed systems (HPDS) group

The research group has 5 professors, 2 adjunct professors, and one postdoctoral researcher. The group does research on distributed and parallel systems, their architecture, design, implementation and behavior.

Assessment

Most visible is perhaps its work on high-performance visualization at high resolutions. The group is also involved in several inter-disciplinary projects. It has an impressive number of collaborators, both internationally and nationally, both industry and academia. The funding for staff and infrastructure is just sufficient.

Overall grade: 3

Recommendations

The committee offers the following recommendations

- Increase the quality and quality of publications.
- We further encourage the group to explore nontraditional and inter-disciplinary fields.
- Increase the efforts to be part of EU projects.

Information access group

The group has one professor, one assistant professor and one postdoctoral researcher. In addition, there are three adjunct researchers and 6 PhD students. The research is on fundamental structures and concepts for run-time systems supporting extreme scale information access applications in cloud environments, as well as the development of novel multi-media applications integrating sensor networks, video search and production in real-time.

Assessment

The IA group is strongly connected to the information Access Disruption (iAD) consortium, an international collaboration involving Microsoft, Accenture, Cornell, Dublin CU, BI, NTNU, UiO, and UiT as main partners. The consortium is partially funded by the Research Council of Norway, as a Centre for Research-based Innovation (SFI).

The group is heavily depending on external funding (iAD). The network of collaborators including major players in industry as well as strong international universities is indeed impressive. The strong interaction with sabbaticals and visits from PhD students is very positive.

With such a strong research network, it is surprising that the total number of publications is so low.

Overall grade: 3

Recommendations

The committee offers the following recommendations

- There is a strong need to improve the number of high quality papers.

Medical informatics & telemedicine group

The group has 2 professors, 4 adjunct professors (researcher) and 6 PhD students. The MI&T group members have received many external grants, among them the Tromsø Telemedicine Laboratory 2007-2014 (NOK 80M from Research Council of Norway (RCN). The group members are involved in several research areas: Integrated Medical Sensor, Health Terminals for Personalized Health Care being tools and procedures for monitoring and control of patients, and Health Intelligence defined as use and development of knowledge to improve the health of the population.

Assessment

The group demonstrates a large variety of different collaborations, both in the medical area, like Norwegian Centre for Integrated Care and Telemedicine (NST) and University Hospital of North Norway (UNN), as well as in academia. An increase in the publication ratio during the last five years is a positive trend. It is now roughly at national average.

***Overall grade*: 3-4**

Recommendations

The committee offers the following recommendations

- The group should increase the focus on EU funds and plan the future funding. There should be great opportunities for more EU funding.

- We encourage strengthening the connections to the hospital sector.

Open distributed systems (ODS) group

The academic staff in the group consists of 3 associate professors, one adjunct professor and 5 PhD students. The research is centered around middleware that facilitates the construction of applications of various kinds, with an emphasis on interoperability and adaptability issues.

Assessment

The group is part of a number of projects that focus on quite different research aspects and application areas. The group has a large research network and collaborates in many projects. The impression is that the group is more focused on running projects than publishing research papers.

***Overall grade*: 3**

Recommendations

The committee offers the following recommendations

- Increase the number of journal publications

6.8 Vestfold University College

The Department of Micro- and Nano Systems Technology (IMST), one of four departments within Faculty of Technology and Maritime Sciences (TekMar) at Vestfold University College (HiVe), is evaluated. Its PhD program within Applied Micro- and Nano Systems received accreditation in 2010. The department has seven groups, with 18 professors and associate professors working in one or more groups. The groups, focusing on micro/nano research and technology, cover Bio-MicroElectroMechanical Systems (BioMEMS), Micropower (Micro), Micro-Optical-Electro-Mechanical-Systems (MOEMS), Radio-Frequency-Micro-Electro-Mechanical-Systems (RFMEMS), Fabrication Integration Packaging (FIP), Nanosystems integration (NANO), Micro-Nano-Electro-Mechanical-Systems (MNEMS), with a strong experimental emphasis in the research work.

There is an ongoing process between Østfold University College (HiØ), Buskerud University College (HiBu) and Vestfold University College (HiVe) with the aim to merge the three institutions from January 1, 2013.

Assessment
The group structure is not formalized, with a focus on a few projects or a strong integration within the groups.

The publication record is good.

There is a large potential in the ongoing activities and the international program is good. The scope of the research is very broad and may need to be refocused depending on funding and available resources.

It is not clear what the advantage for the Department is from the planned merger with other Universities.

Grade: 3

Recommendations
The committee offers the following recommendations:

- Research should be more focused, in contrast to the current situation where the Department tries to cover a very broad spectrum of topics through small groups.

- A stronger research collaboration outside the department is encouraged, with plans for sabbatical programs for faculty.

- A postdoctoral recruitment plan should be established.

6.9 Østfold University College

The faculty of Information Technology at ØUC is located at the campus in Halden and has about 30 employees. They run four bachelors programs on ICT topics and one master program in applied computer science. The number of students is close to 400.

The research activities are not organized in formal research groups due to the small size of the faculty. Only a few employees are actively conducting ICT research, and for some of them this work is their PhD studies. Research from single ØUC employees is documented.

The three university colleges in Buskerud, Vestfold and Østfold have started a process for merging the three units. They aim to have the new, large university college in place at the beginning of 2013. The main reason for merging the colleges is the formation of bigger and stronger academic units, resulting in better educational programs. In particular, a PhD-program in applied computer science is a main goal.

Assessment
The outcome of the research activities is weak. There is no research agenda, only a few isolated persons going in their own direction. The number of publications is in general low and the quality of the publications (e.g. the ranking of journals where papers appear) is also low.

Overall grade: 1-2

Recommendations
The committee offers the following recommendations. The recommendation from the 2002 review largely remain valid.

- In order to create a research environment with more strength and visibility, a more focused research agenda and a more active research leadership is needed.
- There should be a plan for how to expand the research activities. This could include strategies to obtain additional funding for research.
- Ideas to reduced teaching for young people active in research, and external recruitment of strong researchers should be seriously considered.

7. Evaluation of Selected Research Institutes

In the following we offer a more detailed discussion of each of the four research institutes that participated in the evaluation. This will be done at the level of research groups and we provide some specific recommendations that we hope will be useful going forward.

Following the tradition of previous evaluations, we have assigned a grade to each research group, reflecting our view on the qualities, challenges and opportunities we were left with after the self-evaluations, interviews, and discussions. These grades, ranging from 5 (international leadership, visibility, and vision) to 1 (substantial structural problems and limited impact and productivity), are assigned in a relative fashion across the groups.

The evaluation committee wishes to emphasize that we have not had information about how grades were assigned in past evaluations and ask that grades not be compared across the 1992, 2002, and 2012 evaluations as the metrics are likely different.

7.1 Norwegian Defense Research Establishment (FFI)

FFI is a multi-disciplinary research institute characterized by a focus on Norwegian Defense Research. The research at FFI is organized in projects. The projects are organized in 5 divisions, each division with a division head, 1-3 research directors, approximately 10 project leaders and on the average 100 scientist/engineers and technicians participating. Three divisions are evaluated.

Two of the research groups to be evaluated (Information security and Wireless communication networks and services) are within the Information Management division, two groups (Hyperspectral imaging and Radar) are in the Land- and Air Systems division, and the Underwater robotics and sensors group is within the Maritime system division.
Due to its focus on Norwegian Defense Research, the institute addresses the challenges of the client, and there is a major emphasis on understanding its needs and requirements. A 4 years rolling research plan is worked out each year, taking into account new developments in science and technology as well as the needs of the client.

There is a limited focus on PhD education, with 4 PhDs graduated in the past three years within the evaluated groups. No Master level graduates have been reported.

Assessment
As stated in the self-evaluation report, a substantial fraction of the reports and deliverables from most of the projects at FFI are classified, and not reported in the scientific literature, and thus are not included in this evaluation. The evaluation of the committee is therefore necessarily based on incomplete information. Budget data have been given only for two of the five groups.

FFI research is characterized by good understanding end user needs, in-house capabilities of doing demonstrators, with the goal to transfer results to industry for production.
The relationship with universities should be strengthened.

Recommendations
The recommendations of the committee are based on limited information since part of the research is classified.

The topics of research are of both strategic and societal importance and the institute should improve its involvement in education. The collaboration with universities should be improved, expanding ways to study classical problems through unclassified research related to the topics of interest for the Institute.

Information management division

Within the division, two groups with a total of 13 researchers are evaluated, the Information Security Group and the Wireless communication network and services group.

Both groups are involved in different projects under the FFI research program *Network-based defense*. The program consists of projects covering a broad range of aspects.

The Wireless communication network and services group research focuses on communication systems with low bandwidth.

Assessment

As mentioned in the general comments, most research and results are classified. This results in restrictions on publishing and cooperation with academia and makes an in depth evaluation challenging.

Grade: 2

Recommendations

The committee offers the following recommendations

- It is suggested to further enhance management practices to better handle multiple clearance levels in documents and research to increase and expand opportunities for collaborations in research and education.

- For information security, it is encouraged to improve national collaboration and leadership on the topic security.

- In the area of wireless communication systems, there is a potential to increase the focus on interoperability and robustness.

- Long-term research activities should be strengthened.

Land- and air systems division

Within the division, two groups with a total of 11 researchers are evaluated, the Hyperspectral imaging group and the Radar group.

The Hyperspectral imaging group covers the entire information chain of a hyperspectral imaging system.

The Radar group focuses on heterogeneous networks, on the problem of interoperation of networks, also across nations, and on satellite sensors.

Assessment

Publication of results is often restricted due to classified work, but the division has a good publication record.

One of the strengths of the research is that all phases from design to prototype and field measurement are covered and the connection with industry is good.

Grade: 3--4

Recommendations

The committee offers the following recommendations

- The research should consider also civil applications, to improve collaborations with universities on sensors and imaging.

- It is suggested to further improve management practices to be able to handle multiple clearance levels in documents and research to further increase opportunities for collaborations in research and education

Maritime systems division

The Underwater robotics and sensors group, which has 13 researchers, is evaluated. The research is focused on autonomous underwater vehicles (AUV). Three out of its four subgroups are evaluated: Navigation, Synthetic aperture sonar (SAS), Autonomy and automatic target recognition.

The division is characterized by intense collaboration with industry.

Assessment

The research is focused on research to support both civilian and military production, with strong collaboration with one industry.

The publication record submitted for the evaluation is somewhat limited.

Grade: 2

Recommendations

The committee offers the following recommendations

- It is recommended to increase the number of publications and to collaborate more with universities, in particular with NTNU.

7.2 Simula Research Laboratory

Simula Research Laboratory was created in 2001 following a national competition to establish a national research institute focusing on ICT research. The result of the competition was that three groups, all originally located at the University of Oslo, were selected and Simula was formed around these three groups and offered conditions and resources beyond that of other national universities and research institutes. The three original research groups remain the ones originally selected, comprising communication systems, software engineering, and scientific computing.

The research culture of Simula strives to combine academic and industrial cultures through managed research. The organization changed substantially since the last external evaluation (2009) and strives to mimic a corporate model.

The funding from RCN is established on a 5+5 rolling funding model with an international evaluation every 5 years. These evaluations and numerous other measures have found Simula to be a success and Simula has established itself as a national and, in many cases, an international leader with a substantial impact beyond the borders.

While the base funding from RCN has been held steady over an extended period of time, Simula has found other vehicles to continue to grow in size, reaching a scientific staff size close to 100. Within Simula there are currently four centers, one being a Center of Excellence and three Centers for Research Driven Innovation. Furthermore, there are strong collaborative agreements with major industry such as StatOil, GE, CISCO etc

The resources of Simula allow for a broad international recruitment, reflected in a diverse and international workforce and less recruiting problems than mentioned by most other national institutions. Over the last decade it has developed an expanding educational component focusing on PhD students and MSc students, almost exclusively in collaboration with University of Oslo. More recently, a partnership with the University of California, San Diego has been formed with the goal of having a dual degree program between UCSD and University of Oslo. The details and financing of this partnership remains unknown.

Assessment
Simula has, by most measures, been a substantial success and lead to the creation of a center of international visibility. Many of the research activities provide international leadership and Simula is a substantial resource for research and education in ICT. It takes on an increasing role as a resource for education of both MSc and PhD students, although focus remains on local students from the Oslo region.

The publication activity for Simula is generally high and positioned in journals of high impact. The connections to industry are strong and provide examples for other universities and research institutes on how to establish such connections without impacting the depth of the research.

During the last decade, the interest in attracting EU funding has been marginal, possibly due to a situation where local resources were seen as being sufficient. Past reviews of Simula has encourages that this be addressed and there are now signs of such enhanced effort

through increased proposals and the hiring of a proposal coordinators focusing on such opportunities.

The 2009 evaluation, while largely supportive, raised some concern about the organizational structure of Simula - a structure that was close to the one originally implemented for a much smaller organization. As was the case after the 2005 evaluation, Simula has been proactive in addressing concerns and has also implemented a new and more appropriate structure following the 2009 evaluation. The leadership should be commended for such flexibility and readiness to change.

Recommendations

As successful as Simula has been during the last decade, it seems timely that it seeks to impact not just the Oslo region but the entire Norwegian educational, research and development enterprise. This should be accomplished by the formation of partnerships with Norwegian universities and university colleges to strengthen research and educational activities. This will also increase the possibilities for a broader recruitment from across Norway and enable a deeper impact of the substantial investment made in Simula. To further strengthen this, the utilization of Professor II positions should be expanded beyond the University of Oslo.

The committee also suggests that Simula develop plans for realistic future financial scenarios such as a flat level of basis funding and how to absorb such changes without impacting the current research environment and impact. Initial steps to seek more substantial EU funding should be continued and expanded.

Based on the information provided, the committee was unconvinced about the benefits to Simula and Norway of the recent agreement with UC San Diego. While an international outlook in research and education is essential, commendable, and to be encouraged, it should not be done at the expense of further distancing Simula from having a broader and deeper impact on Norwegian research and education at national universities. The committee suggests that this arrangement be revisited after an initial pilot phase to evaluate if this is indeed beneficial, scientifically and in relation to its financial impact, not only to Simula but to Norway.

The urgency of this is further emphasized by a lingering perception by other universities of what is perceived as a model favoring the University of Oslo as well as some initial signs of tension between Simula and University of Oslo. The committee feels that it will be in the best interest of Simula to seek to further strengthen its visibility and impact across the entirely national ICT community and reach out to form and strengthen educational and research bonds with institutions beyond University of Oslo to help address these concerns.

Communication systems (CS)

The group consists of two subgroups. Network resilience and data center computing is the largest group with about ⅔ of the staff and it has very strong connections to the University of Oslo, with some projects funded entirely through the university. The research focus is clearly of national interest to help ensure a robust national network. Media performance analysis focuses on Quality of Service and Quality of Experience questions to ensure performance of distributed multimedia.

Assessment

The group has a good publication record and good industry links. Moreover, it has very good connections to other Norwegian partners as well as with other international renowned institutes and individual researchers. The group has strong competence in the areas where they have been active during the last years, particularly resilience and robustness of networks and has developed robust collaborations with industrial partners, in particular on the network side. Recently, there has been a stronger shift due to more experimental and measurement based research, which is appreciated.

Grade: 4

Recommendations

The committee offers the following recommendations

- Group should continue and strengthen its efforts to take leadership in national network initiatives
- Further increase publications in the best journals, internationally.
- Seek to increase diversity and EU funding.
- New basic research topics that become relevant in the future need to be identified in an ongoing manner.

Scientific computing (SC)

The scientific computing group is the largest organizational unit with close to 30 academic staff members and a substantial number of PhD students. There are three major subgroups, focused around biomedical computing through a Center of Excellence, cardiac modeling, and computational geoscience. All activities in the scientific computing group are centered around the development and application of advanced computational modeling techniques for solving large and complex problems of national interest. It is also engaged in the development of software environments to help the solution process by non-experts and works closely with industrial partners and hospitals in many of the research activities.

Assessment

The group has, since the beginning of Simula, been performing very well and has had a substantial impact, both nationally and internationally. It has a broad international network of collaborators and has experienced a steady growth in publications and activities during the last years, including a substantial publication activity through books. While the group has had substantial success with attracting national research funding, there has been less focus and success with EU funded projects. The connection to StatOil is strong and serves as a substantial source of funding and collaboration.

Grade: 5

Recommendations

The committee offers the following recommendations

- Increase EU funding
- Seek to increase role as national leader and glue between university research and computational science in an industrial setting.
- Seek to increase clinical component for biomedical modeling to maximize impact
- Develop emphasis on verification and validation activities to enable full predictive modeling.

Software engineering (SE)

The software engineering group comprises two groups, focusing on fault avoidance, fault detection and project management and cost of large and complex software systems. With software deeply embedded in all aspects of modern society, failures come at high cost. The groups have a unique leadership position globally and are involved in a large range of projects, driven by real applications and problems of deep societal impact.

Assessment

The group has an excellent research and publication activity and continues to strengthen an already strong international profile. It is well funded from various sources and has a broad collaborative network, both within academia and through industrial partners. With an emphasis on impact, the committee feels that the group should strive to play a stronger national role as leader and coordinator of research networks.

Grade: 5

Recommendations

The committee offers the following recommendations

- Increase national collaborations to take on responsibility as a national leader to coordinate and drive national activities in software engineering.

- Lead to build networks, collaborations, and national activities.

7.3 SINTEF ICT

SINTEF ICT was established as a research institute inside SINTEF in 2004 through a merge of three research institutes in SINTEF with ICT as a common discipline. SINTEF, which was established as a private foundation in 1950 on the university campus of Trondheim, is the largest independent research organization in Scandinavia. It is a non-commercial research foundation with subsidiaries that employs 2100 people and has expertise in natural sciences and technology, environment, health and social science.

SINTEF ICT is divided in 9 research departments decomposed each into research groups. The two groups that are part of the evaluation are the 'Human Computer Interaction' (HCI) group and the 'Software Process Improvement and Knowledge Management' (SPI) group that belong to the 'Networked Systems and Services' and 'Software Engineering, Safety and Security' groups, respectively.

Assessment

The two groups are financially in a good position and despite the fact that SINTEF is a non-commercial foundation, the annual budgets show a surplus of about 10%. However, both groups feel vulnerable due to (a) their strong dependency on industrial contract based funding and (b) to the uncertainty of funding priorities of their two main external sources for funding (EU and Research Council). They also see the low level of basic funding as a threat to their involvement in basic research.

The research focus is on areas important to Norway with 'technology for a better society' as their broad vision. The two groups conduct applied research, which is relevant to industry as it focuses on fundamental questions of importance for industry. They have succeeded in acquiring high academic capacity and show a good/very good publication performance. They are successful in getting EU funding well above the standard level of other Norwegian institutions.

Recommendations

Despite the demand, expressed during the hearings, for an increased base funding, the committee recommends being prepared for a situation with no base funding and to elaborate plans accordingly. SINTEF has acquired advanced competencies in some aspects of Software Engineering that are of paramount value for MSc and PhD students. The committee recommends that SINTEF increases its educational impact by increasing education activities to Norwegian universities. The committee acknowledges SINTEF collaboration with some universities in Norway, and suggests strengthening these links for research and teaching and to maintain/build connections to a broader group of national universities having similar research concerns. SINTEF could take the lead in building a Norwegian network on empirical SE that would have the critical mass to increase Norwegian visibility and offer leadership at the international level on this area of research. SINTEF is successful in getting EU funding but dependent of research priorities set by the EC. The committee recommends envisioning long-term mechanisms to be part/influence EU frameworks writers.

Software process improvement and KM (SPI) group

The SPI group was formally established in 2005. It comprises 1 chief scientist, 3 senior scientist and 2 research scientists. It functions as a cohesive and motivated team with members' interactions and shared duties. The activity is performed in Trondheim and is mainly based on empirical evaluations and action research to get evidences and to gain and synthesize knowledge for improving the principal mechanisms of software development. More precisely, the group has prioritized research on three areas, evidence-based SE, agile software development and global software development.

Assessment

The scientific quality and productivity of the group in terms of publications and conference proceedings is very good. The SPI group has increased its number and quality of publications with an average of 5 journal papers per year during the reporting period and an average of 2.2 publications per individual and per year, which is very good. The number of citations is growing as an indication of the interest of the ISD community for the papers published by the group. The group has extensive collaborations nationally and internationally as well and has been involved with the organization of international conferences. The group is highly visible in the agile and empirical studies communities both at the national and international levels. A reasonable number of PhD's has been supervised and an equivalent number is under supervision. Participation in projects with industry and EU is very high. The group produced 3PhD graduates during the reporting period and is currently involved with the supervision of 5 doctoral students.

Grade: 4

Recommendations

The committee offers the following recommendations

- The activities of the group within its sphere of competence have been carefully selected and the committee recommends continuing to prioritize subjects on emerging and irreversible trends in SE.

- Given the leadership of the group on empirical SE and its strong connections with other Norwegian universities involved in this topic, the committee suggests taking the lead to set up a Centre of Excellence on this subject in Norway.

- The committee recommends maintaining external funding to support students and long term research.

HCI group

The HCI group consists of 1 senior researcher and 6 research scientists. The group has quantitative and qualitative competence from psychology, media science and informatics that enable to cover a large range of questions in the HCI domain. The activity of the group is organized around two main topics namely, networked societies and decision-making in complex environments. In the former the aim is to understand the use of social media in order to identify the characteristics that are important for users whereas the latter research on how to present information to decision makers in order to facilitate their work. The group is located in Oslo. The group has developed a LivingLab and is a partner of the Centre for Service Innovation, a Center for research-based Innovation, that started in 2011.

Assessment

The scientific production of the group in terms of publications is good. However, the bibliometric analysis shows that the number of citations is moderate. The written materials as well as hearings were less efficient in demonstrating focus in the research activities. Research is performed within industrial projects in collaboration with universities and particularly with UiO. On the international side the group is successful in raising EU fund and maintains relationships with some of the international partners involved in these projects. There is no mention of PhD and/or master supervision.

Grade: 3

Recommendations

The committee offers the following recommendations

- The evaluation committee encourages the group to increase the quantity and quality of journal publications. In order to achieve this objective it is necessary to more carefully plan a research strategy that fosters the synergy among group members.

- The great strength of this group is its LivingLab and the committee recommends to more systematically taking advantage of it.

- The group should seek to involve students in their work.

7.4 University Graduate Center at Kjeller (UNIK)

UNIK is a foundation, owned by the University of Oslo (UiO), the Norwegian University of Science and Technology (NTNU) in Trondheim, the Norwegian Defense Research Establishment (FFI) at Kjeller, and the Institute for Energy Technology (IFE), also at Kjeller. UNIK was established in 1987, with the mission to contribute to education in science and technology, at the MSc and PhD level, based on the close proximity and connection to the research infrastructure in the Kjeller area. Collaborations are ongoing with numerous public sectors and local industry environments. A Telecom research center previously located at Kjeller, one of the original founders of UNIK and playing an important part in the start-up of the center, has been relocated and its influence has been reduced over time.

The goal of UNIK is to contribute to increased research collaboration between the Kjeller research institutes and UiO/NTNU, to the benefit of all.

The center provides research based teaching and supervision for MSc students and PhD candidates of the owner universities and other universities, some of them for short periods, some for the entire period of their thesis, benefitting from the research infrastructure in the region. The environment is well suited for students who want to work in more applied topics in an industrial environment. UNIK supports thesis work carried out in the Kjeller institutes.

UNIK organizes teaching of master and PhD courses, given by scientists mainly from the Kjeller institutes and industry, with a good infrastructure for distance teaching, used in 75% of the courses. 52 courses were organized in 2010.

UNIK has 4 priority areas of research:
1. Networks, information security, and signal processing for communication
2. Electronics and photonics
3. Cybernetics and industrial mathematics
4. Energy and environment

Of the two research groups that are presented for this evaluation, the “Cybernetics and Communication group” is mainly from research priority area 1, with one scientist from area 3.

The “Electronics and Photonics group” is mainly from area 2, with one scientist from area 4. The two groups include all the present 9 scientific staff members (six scientific staff positions at UiO and 3 full time professors with more that 80% work-load from NYNU), as well as 4 adjunct professors (20% positions) and 4 post-docs. 22 PhDs graduated from the evaluated research groups in last three years.

Assessment
The research groups are active in research and are formed by competent and productive academic staff, as demonstrated by their publication record. However, external funding has been progressively reduced over time from 40% to 24%.

While there is flexibility to start new collaborative activities with near-by research institutes and industry, the research is not very focused, presenting a large variety of topics and subtopics for the limited dimensions of the research groups. In addition, in UNIKs portfolio of research activities and profile of its scientific staff, there is a heritage from the early days of the center when local telecom industry played a major role in the development of UNIK, and it does not adequately reflect the present research profile of the Kjeller research institutes.

The teaching activity of the center takes advantage of research institutes staff and it provides also a good infrastructure for distant education. However, the cooperation with the research institutes does not seem to be formalized in external research contracts.

The center does not provide a substantial own infrastructure, since it relies on external institutes, and there are not plans for its further development.

A critical issue concerning staff is that there are no clear plans for replacing the fairly consistent percentage of staff near retirement.

Recommendations

The center should increase the relation with local industry in formal ways, including controlling funds. The rationale for maintaining UNIK with its current level of activity, impact, and funding is questioned by the committee. This is further emphasized by pending retirements, which could further decrease the level of activity. To maintain the center, the current situation of declining funding and lacking research focus should be reversed, possibly by identifying a new research focus for UNIK.

Perhaps, a different organization structure should be put in place to emphasize the role of the center in promoting applied research by PhDs and to enhance collaboration between universities and institutes in the region.

Cybernetics and communications group

The group is presently composed of 5 full professors/senior scientist (4.8 person year), 4 adjunct positions and 4 post-docs. In addition, there are two open adjunct professor position in the security area. There is one Professor Emeritus in the group. The adjunct staff teach and supervise Ph.D students. Most of the full professors have substantial industrial experience, complementing the industrial experience of the adjunct staff.

All tenured staff is closely associated with either UiO or NTNU, and their research strategy is a specialization of the research strategy of the group they belong to in their original institutions or Center of Excellence. The result is a focus on a variety of different aspects of mobile and wireless communication and estimation and model theory within cybernetics. Currently the strategy is implemented with focus on the following selected areas

- Estimation and modeling theory in navigation and tracking
- Information Theoretic Aspects of Multiuser networks
- Information security
- Systems for Cognitive spectrum allocation
- Internet of things
- Wireless sensor and sensor networks
- Ad hoc wireless networks

Assessment

Due to the small size and the broad coverage, the group feels a need to be part of multiple networks and have close collaboration with others. On the other hand, the group suffers from the general characteristics of the center, with a weakness in funding, many activities externalized to the institutes in the region, and a systematic difficulty in plans for replacing retiring professors.

The group presents an excellent publication record, with papers published at an excellent rate in highly ranked journals.

Grade: 4

Recommendations

The committee offers the following recommendations

- The group should take initiative to tackle recruitment challenges and to improve local industry connections.

Electronics and photonics group

The research group 'Electronics and Photonics' at UNIK consists of four members with a common technical background, but the members usually work on different research projects and in different application areas for their research. The research is characterized by applied research, with collaborations well matched to present activities at Kjeller and with projects, which are interesting for students.

Assessment

One weakness of the group is the age of group members, with several planned retirements in the future years.

The publication level is excellent, with papers published in top journals and well cited.

Grade: 4

Recommendations

The committee offers the following recommendations

- The recruitment challenges of the group should be solved, to ensure the continuity of the group.

Appendices

Appendix A: Mandate for the Evaluation Committee

The Committee is requested to evaluate scientific activities with respect to their quality, relevance and international and national collaboration. The Committee is also requested to evaluate the way in which research in ICT is organized and managed.

The conclusions in the committee's report should lead to a set of recommendations and possible scenarios concerning the future development and prioritization of research in ICT in Norwegian universities, university colleges and relevant contract research institutes, including challenges related to recruitment and possible reductions in the number of permanent scientific positions.

Specific aspects to be considered and described are:

1. General aspects

    - In which areas are Norwegian research in ICT strong? In which areas of are Norwegian research in ICT weak?
    - Are there areas within ICT in which Norwegian research is at the leading edge of the international scientific development?
    - Is Norwegian research in ICT being carried out in areas that are regarded as important and relevant by the international research community? |
    - Are there any particular differences between Norwegian research in ICT and research carried out in most other countries?
    - Is there a reasonable balance between the various fields of research in ICT in Norway, or is research absent or underrepresented in any particular field?
    - Are any areas overrepresented, in view of the scientific quality or relevance of the research being carried out?
    - Is there a reasonable degree of division of labor with regard to research activities among institutions at the national level, or should this aspect be improved?
    - Is there an adequate degree of national and international mobility?
    - Is the Norwegian research in ICT relevant to the needs of industry and society?
    - Do research groups maintain sufficient contact with industry and/or the public sector?

2. Academic departments.

    - Are the academic departments adequately organized?
    - Is scientific leadership being exercised in an appropriate way?
    - Do individual departments carry out their research as part of an overall research strategy?
    - I Are the academic departments adequately organized?
    - Is there sufficient collaboration between research groups within individual departments?

- Are there satisfactory policies in place guiding the recruitment and handling of employees
- Are the efforts to increase gender balance in academic positions satisfactory?
- In which way have the previous evaluation of research in ICT (2002) and the associated national strategic plan been used by the departments in their own strategic planning?

3. Research groups (all institutions)

3.1. Strategy, organization and research leadership

- Has the research group developed a satisfactory strategy for its research? Is it implemented?
- Is the size and organization of the research group reasonable?
- Is research leadership being performed in an appropriate way (e.g. in execution of project management)?
- Is there a reasonable and efficient distribution of tasks and responsibilities within the research group?

3.2 Research activities, staff and scientific production

- What is the scientific quality of the research group as judged by the significance of contributions to its field, prominence of the leader and team members, and scientific impact of their research?
- Is the scientific production, e.g. the number of scientific publications and Ph.D. theses awarded, reasonable in terms of the resources available?
- How is the long-term viability of the staff and facilities evaluated in view of future plans and ideas, staff age, facilities, research profile, and new impulses through recruitment of researchers?
- Do the group play an active role in dissemination of its own research and of new international developments in its field to industry and/or public sector?

3.3. Research collaboration (national, international, industry)

- Is there sufficient contact and co-operation with other research groups nationally? In particular, how is the co-operation between academic research groups and the contract research institutes?
- Is the level of contracts and joint projects with external partners satisfactory?
- Is the research group involved in interdisciplinary/multidisciplinary research activities at a satisfactory level?
- Do the research group play a satisfactory role in creating and establishing new industrial activity?
- Is the international network satisfactory, e.g. in terms of contact with leading international research groups, number of guest researchers, and number of joint publications with foreign colleagues?
- Is the group's involvement in international programs satisfactory?

- Is the participation in international professional committees, peer review, work on standardization, and other professional activities satisfactory?

4. Research infrastructure (RI)

- Describe the current situation for national RI critical to research within ICT in Norway.
- Describe future needs with regard to modern RI within ICT in Norway.
- Is there sufficient national co-operation with regard to the use of RI?
- Is the use of international facilities satisfactory, or should utilization be improved by introducing special measures?
- Is there a sufficient awareness of new RI opportunities in Europe and globally, and are there plans for active participation in such RI projects?

5. Training

- Does scientific staff play an active role in stimulating interest among young people for their field of research?
- Is recruitment to doctoral programs satisfactory, or should greater emphasis be put on recruitment in the future, including strategies aimed at improving the gender balance?
- Are there sufficient educational and training opportunities for Ph.D. students?

The Committee's written report is expected to address the questions posed above. The assessments and recommendations should be at research group, departmental, institutional (universities only) and national level.

Please feel free to address other relevant aspects of Norwegian research in ICT that are not addressed above.

Appendix B: Biographies for Committee Members

Professor Jan S Hesthaven, Brown University, USA

Professor Hesthaven recieved an M.Sc.(1991), Ph.D(1995), and Dr. Techn(2009), all from the Technical University of Denmark (DTU). Following graduation in August 1995, he was awarded an NSF Postdoctoral Fellowship and was appointed Visiting Assistant Professor in the Division of Applied Mathematics at Brown University. In 1999, he was appointed Assistant Professor of Applied Mathematics, with promotion to Associate Professor in 2003 and Professor of Applied Mathematics in 2005.

From 2006-2010 he served as the Associate Chair of Applied Mathematics and in Oct 2006 he was called upon to be the first faculty director of the Center for Computational and Visualization (CCV) at Brown. Since July 2010 he also serves as the Deputy Director of the newly created NSF Institute for Computational and Experimental Research in Mathematics at Brown University.

In Sept 2000 he was awarded an Alfred P. Sloan Fellowship, in July 2001 he was awarded a Manning Assistant Professorship, and in March 2002, he was awarded an NSF Career Award. In recognition of his teaching he was, in May 2004, awarded the Philip J. Bray Award for Excellence in Teaching in the Sciences at Brown University.

His main area of research centers on accurate and efficient methods for the solution of time-dependent partial differential equations, often requiring high-performance computing to enable the modeling of complex applications. He has published two monographs, several editorial volumes, and close to 100 research publications in leading journals. Much of this work is done in close collaboration with students and postdoctoral fellows, who have gone on to exciting career in industry and academia. He serves on the editorial board of 6 international journals, and acts as a consultant to companies and federal funding agencies and foundations worldwide.

Professor Susanne Albers, Humboldt-Universität zu Berlin, Germany

Susanne Albers is Professor of Computer Science at Humboldt-Universität zu Berlin where she has been since 2009. She received her PhD degree from Saarland University, Germany, in 1993 and worked as Research Associate at the Max Planck Institute for Informatics, Saarbrücken, until 1999. During that time she was postdoc at the International Computer Science Institute in Berkeley and visited various scientific institutions in Europe, the US and Japan. In 1999 she was appointed associate professor at the University of Dortmund. From 2001 to 2009 she held a chaired professorship at the University of Freiburg. Since June 2009 she has been head of the research group on Algorithms and Complexity at Humboldt-Universität.

Her research interests are in the design and analysis of algorithms, with emphasis on online and approximation algorithms, algorithmic game theory and algorithms engineering. She has published 90 papers in peer reviewed journals, conferences and books and edited five conference proceedings. She has served on the program committees of the most prestigious theory conferences STOC, FOCS and SODA and chaired the leading European conferences ICALP, ESA and STACS. Since 2008 she has been Editor-in-Chief of the ACM Transactions on

Algorithms. She has also served on the editorial boards of five additional international journals and two conference proceedings series. She is currently member and vice-chair of the computer science panel of the German Research Foundation.

In 2008, for her research contributions, she awarded the Gottfried Wilhelm Leibniz Prize of the German Research Foundation, which is the highest honor in German research and includes a grant of 2.5 million Euros. She is a member of the German National Academy of Science, Leopoldina, and a Fellow of GI, the German Association for Computer Science.

Professor Colette Rolland, University Paris Panthéon Sorbonne, France

Colette Rolland is Professor at the University Paris 1 Panthéon-Sorbonne in the Informatics & Mathematics department since 1979 and is also an associated professor at the University of Loughborough, UK. She got her PhD Degree Co in Sciences and its 'thèse d'état' as well at the University of Nancy.

Her research interests lie on topics such as conceptual modelling, methodologies and CASE tools, method engineering & CAME tools, requirements engineering, business process modelling, co-evolution, IS and business alignment and change management. She has been involved in a large number of European research projects and she is used to lead cooperative research projects with companies.
Colette has an extensive experience in supervising PhD theses (110); she published about 350 reviewed papers in Journals and Conferences, has been editor of 25 Conference Proceedings, is member of the board of 10 International Journals and has delivered more than 60 keynote talks in International Conferences.

She is an IFIP officer, IEEE member and received several awards such as IFIP Silver Core, IFIP service Award, Franqui's Foundation award (Belgium) and European award of 'Information Systems'. She is Doctor Honoris Causa of the University of Geneva.

Professor Bo Wahlberg, KTH Royal Institute of Technology, Sweden

Bo Wahlberg received the M.Sc. degree in Electrical Engineering 1983 and the Ph.D. degree in 1987 from Linköping University, Sweden. In December 1991, he became Professor of the Chair of Automatic Control at the Royal Institute of Technology, Stockholm, Sweden. In 1999 to 2001 he was vice president of KTH.

He was a Fulbright visiting professor at the Department of Electrical Engineering, Stanford University, USA, August 1997 - July 1998 and August 2009 - June 2010.

He is a past chairman of the IFAC Technical Committee on Modeling, Identification and Signal processing and a Fellow of the IEEE for his contribution to system identification using orthonormal basis functions. He has been associate editor and guest editor for Automatica.

In 2010 he was the chairman of Swedish Research Council Committee on Signals and Systems.

His research interests include system identification, modeling and control of industrial processes, and signal processing with applications in communication and autonomous systems.

Professor Georges Gielen, Katholieke Universiteit Leuven, Belgium

Georges G.E. GIELEN received the MSc and PhD degrees in Electrical Engineering from the Katholieke Universiteit Leuven, Belgium, in 1986 and 1990, respectively. In 1990-1991 he was visiting researcher and lecturer at the University of California, Berkeley (USA). From 1991 on he was appointed at the Department of Electrical Engineering (ESAT) of the Katholieke Universiteit Leuven, where he currently is Full Professor. He presently is the Head of the Microelectronics and Sensors (MICAS) research division, which includes five professors and more than 70 PhD students. He is also the Chair of the Leuven ICT (LICT) research center, and the PI coordinator of the Leuven CHIPS Center of Excellence.

His research interests are in the design of analog and mixed-signal integrated circuits, and especially in analog and mixed-signal CAD tools and design automation. He is coordinator or partner of several (industrial) research projects in this area, including several European projects (EU, MEDEA/CATRENE, ESA). He has authored or coauthored 7 books and more than 450 papers in edited books, international journals and conference proceedings. He regularly is a member of the Program Committees and sometimes serves as Program/General Chair of major international conferencesas well as member of the editorial boards of international journals.

He received the 1995 Best Paper Award in the John Wiley international journal on Circuit Theory and Applications, and was the 1997 Laureate of the Belgian Royal Academy on Sciences, Literature and Arts in the discipline of Engineering. He received the 2000 Alcatel Award from the Belgian National Fund of Scientific Research for his innovative research in telecommunications, and won the DATE 2004 conference Best Paper Award. He has been elected Fellow of the IEEE, served as elected member of the Board of Governors of the IEEE Circuits And Systems (CAS) society, as appointed member of the Board of Governors of the IEEE Council on Electronic Design Automation (CEDA), and as Chairman of the IEEE Benelux CAS Chapter. He also served as the President of the IEEE Circuits And Systems (CAS) Society in 2005, and as Chair of the IEEE Benelux Section. He was elected DATE Fellow in 2007, and received the IEEE Computer Society Outstanding Contribution Award and the IEEE Circuits and Systems Society Meritorious Service Award in 2007.

Professor Barbara Pernici, Politecnico di Milano, Italy

Barbara Pernici is full professor of Computer Engineering at the Politecnico di Milano. She has a doctor in engineering degree (laurea) from the Politecnico di Milano and a MS in Computer Science from Stanford University. Previously she was full professor at the University of Udine (1990-1993) and associate professor at the Politecnico di Milano (1987-1990). In 2010 she has been a visiting professor at Technical University of Vienna teaching a PhD level course.

Her research interests include workflow information systems design, cooperative information systems, adaptive information systems, service engineering and web services, data quality, and computer based design support tools, energy efficiency in information systems.

She has published more than 50 papers in international journals, co-edited 26 books, and published about 350 papers at international level.

She is scientific leader in the European project GAMES (Green Active Management of Energy in Service Centers) and she participated as a unit leader in several ESPRIT and IST European projects. She has coordinated several National Research Council and Italian Research projects. She has been part of the program committee in many international conferences and served as referee for several international journals. She has been program chairperson for IFIP TC8, IFIP WG 8.1 and WG 8.4 Working Conferences, for the International Conference on Information Systems Engineering (CAiSE), and she co-chaired the international conference on Business Process Management (BPM) and the Conference on Cooperative Information Systems (COOPIS). She has been involved in the editorial board Requirements Engineering Journal, for the Journal on Cooperative Information Systems as regional editor, and the Journal on Database Management in the editorial review board, and she is involved in the editorial board of the ACM Journal of Data and Information Quality. She has been referee for evaluation of research projects in Austria, Norway, the Netherlands, Australia, and in Italy, and she has been part of several PhD Committees in Italy and European countries (France, Sweden, Norway, the Netherlands, Belgium) and in Australia and India.

She has been invited speaker at the ServiceWave, RCIS, DEXA, IFIP WG, ICEIS international conferences and in ICWE, REFS, and BPM workshops.

She has been elected chair of TC8 Information Systems of the International Federation for Information Processing (IFIP), of IFIP WG 8.1 on Information Systems Design, and vice-chair of the IFIP WG on Services-Oriented Software. She was awarded the IFIP Silver Core. She has been awarded the IBM Faculty award in 2007 and 2009.

Prof. Pernici is the Dean of the PhD School of Politecnico di Milano.

Professor Thomas Johansson, Lund University, Sweden

Thomas Johansson received the M.Sc. degree in computer science in 1990 and the Ph.D. degree in information theory in 1994, both from Lund University, Lund, Sweden. During 1995-2000 he held various teaching and research positions in the Department of Information Technology at Lund University. Since 2000, he holds a position as Professor of Information Theory at the Department of Electrical and Information Technology.

His scientific interests include cryptology, error-correcting codes, information theory and information security. He has published about 70 papers in journals or book series, and many peer-reviewed conference contributions.

He was the Associate Editor for Complexity and Cryptography for IEEE Trans. on Information Theory (2002–2005) and IEEE Trans. on Information Forensics and Security (2005–2007). He has been program chair of FSE 2003, program co-chair of Indocrypt 2003, and is currently

program co-chair of Eurocrypt 2012 and Eurocrypt 2013. He has served in the program committees of most of the prestigious conferences within his area. He was a recipient of a SSF-JIG (Junior Individual Grant).

During 2003-2007 he served as Deputy Head of Department and a shorter period Director of Graduate Studies. Since 2009 he is Assistant Head of Department at EIT, Lund University.

Professor Torsten Braun, Bern University, Switzerland

Torsten Braun got his Ph.D. degree in Computer Science from University of Karlsruhe (Germany) in 1993. From 1994 to 1995 he was a guest scientist at INRIA Sophia-Antipolis (France). From 1995 to 1997 he was working at the IBM European Networking Centre Heidelberg (Germany) as project leader and senior consultant.

Since 1998, he has been a full professor of Computer Science at University of Bern and director of the research group Communication and Distributed Systems of the Institute of Computer Science and Applied Mathematics at University of Bern. Since then, he has been successfully supervising 15 Ph.D. students. He has been director of the Institute of Computer Science and Applied Mathematics from 2007 to 2011.

During his sabbaticals, he has been a guest scientist at the Swedish Institute of Computer Science, INRIA, Universidade de Sao Paulo, and Lancaster University.

He has been member of the SWITCH board of trustees since 2001 and and vice president of the SWITCH foundation since 2011. SWITCH is the Swiss national research and education network provider.

He is a member of the editorial boards of Elsevier's journals Computer Networks and Computer Communications, and Springer's Informatik Spektrum. He is also editor-in-chief of the Journal of Internet Engineering and chairs the ERCIM (European Research Consortium for Informatics and Mathematics) working group on eMobility.

He received best paper awards from LCN 2001 and WWIC 2007 as well as the Communications Software Award from the GI (German Computer Science Society) subsection on Communication and Distributed Systems (KuVS).

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