

NOKUTs tilsynsrapporter

# Computer Science: Software Engineering, Sensor Networks and Engineering Computing

PhD program at Bergen University College

September 2016



NOKUT 

NOKUT (Norwegian Agency for Quality Assurance in Education) is the controlling authority for educational activity at all Norwegian higher educational institutions. This is achieved, among other, through accreditation of new study programs. Institutions that provide higher education have different authorization to create new study programs. If an institution want to create a provision outside of its field of authorization, it must apply to NOKUT for accreditation.

<b>Institusjon:</b>	Bergen University College
<b>Studietilbudets navn:</b>	Computer Science: Software Engineering, Sensor Networks and Engineering Computing
<b>Grad/Studiepoeng</b>	PhD degree, 180 studiepoeng/ECTS
<b>Studieform</b>	Campus based
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<b>NOKUTs saksnummer</b>	15/695, 16/00149

## Introduction

The external quality assurance performed by NOKUT consists of evaluating the institution's quality assurance systems, accreditation of new provisions and revision of accredited provisions. Universities and university colleges have different self-accrediting powers. For an institution without self-accrediting powers to establish a provision in a certain cycle an application must be made to NOKUT.

Hereby NOKUT presents the accreditation report of Computer Science: Software Engineering, Sensor Networks and Engineering Computing at Bergen University College. The expert evaluation in this report is part of the accreditation process following Bergen University College's application for accreditation of ICT engineering: Software engineering, Communication systems, and Engineering computing (see Section 2 for explanation of the name change) submitted before the application deadline on 1st of November, 2015. This report clearly indicates the extensive evaluation performed to ensure the educational quality of the planned educational provision.

The PhD program in Computer Science: Software Engineering, Sensor Networks and Engineering Computing at Bergen University College fulfils NOKUT's conditions for accreditation and is accredited by resolution of 07.09.16.

This decision does not have limited validity in time. NOKUT will however make a subsequent supervision of the educational provision within three years.

Oslo. 07.09.16



Terje Mørland  
Director General

Information on accreditation of educational provisions (in Norwegian):

<http://www.nokut.no/no/Universitet-og-hoyskoler/Kvalitetssikring-og--utvikling/Akkreditering-av-nye-studietilbud/>

<http://www.nokut.no/no/Norsk-utdanning/Universitet-og-hogskole/Akkreditering-av-studietilbud/Korleis-sokje-akkreditering/>

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## 1 Information regarding the applicant institution

As a university college, Bergen University College does not have power of self-accreditation for educational provisions in the third cycle (PhD). The institution's quality assurance system was evaluated and approved in 2011. The following educational provisions at the institution have obtained accreditation from NOKUT since 2003 (in chronological order by year):

- Mastergradsstudium i samfunnsarbeid, 120 studiepoeng (2006)
- Mastergradsstudium i kunnskapsbasert praksis i helsefag, 120 studiepoeng (2007)
- Mastergradsstudium i informatikk - programutvikling, 120 studiepoeng (2008)
- Mastergradsstudium i klinisk fysioterapi, 120 studiepoeng (2008)
- Mastergradsstudium i barne- og ungdomslitteratur, 120 studiepoeng (2009)
- Mastergradsstudium i undervisningsvitenskap, 120 studiepoeng (2009)
- Mastergradsstudium i klinisk sykepleie, 120 studiepoeng (2010)
- Mastergradsstudium i innovasjon og entreprenørskap, 120 studiepoeng (2011)
- Mastergradsstudium i samfunnsfagdidaktikk, 120 studiepoeng (2012)
- Mastergradsstudium i fysisk aktivitet og kosthold i et skolemiljø, (2014)
- Mastergradsstudium i innovasjon og ledelse – samfunnsfaglig retning, (2014)
- Doktorgradsstudium i Studier av danning og didaktiske praksiser, 180 studiepoeng (2014)
- Mastergradsstudium i areal og eiendom, 120 studiepoeng (2015)

Bergen University College applied for accreditation of ICT Engineering: Software Engineering, Communication Systems and Engineering Computing – 180 studiepoeng/ECTS by the application deadline of 01.11.2015.

### **The University College's description of the program and the applicant's justification for the application**

Bergen University College (HiB) offers a broad range of programs of professional studies within its three faculties: the Faculty of Engineering and Business Administration, the Faculty of Health and Social Sciences, and the Faculty of Education. In total, Bergen University College has approximately 700 staff and 7000 students. In recent years, all three faculties have developed master's degree programs strongly rooted in professional studies. Currently, more than 35 different bachelor's degree programs and 20 master's degree programs with accreditation from NOKUT are offered by HiB. In addition, several lifelong learning courses are offered to active professionals.

In the HiB strategy document for Research, Development and Innovation for the period 2011-2015, adopted by the Board of HiB in 2011, it is stated as a goal that HiB should be able to offer full scale programs of study from bachelor's to PhD level in four prioritized areas. This strategy is rooted in the Strategic Plan document for 2011-2015 (adopted by the College Board as item 77/10), and in the generic requirements and guidelines set out in the Act relating to Universities and University Colleges as adopted by Stortinget (the Norwegian Parliament) April 1st, 2005. The Board of Bergen University College decided in 2010 (item 33/10) to develop one PhD program of study at each faculty, and in 2014 it was decided to develop an additional inter-faculty PhD program in innovation. The Faculty of

Education had a doctoral program accredited in 2014 entitled PhD studies in Bildung and Pedagogical Practices.

The PhD program proposed in the present application is within Information and Communication Technology (ICT) and computing, and is anchored in the Faculty of Engineering and Business Administration. The Faculty of Engineering and Business Administration (in the following, referred to as the faculty) has 180 staff members and 3000 registered students. The faculty is organized in six departments and one research centre, and offers programs at the bachelor's level in all central disciplines of engineering (civil engineering, mechanical engineering, electrical engineering, chemical engineering, and software engineering), along with bachelor's degree programs in business administration, biomedical laboratory science, information technology, and land surveying and cadastre. The faculty offers the largest engineering program at the bachelor's level in Norway. A typical admission profile is about 1000 new first year students, 700 of these in engineering disciplines.

The faculty has formal accreditation for master's degrees in software engineering (joint degree with the University of Bergen, first students admitted in 2004), in innovation and entrepreneurship (started 2013), and in land management (started 2015). Further master's degree programs are offered in collaboration with external universities and include communication systems, subsea technology, and energy technology. The master's degree programs in software engineering and in communication systems, and the associated staff members, constitute an important foundation for the proposed PhD program. The two master's degree programs are in turn based on bachelor's degree programs in software engineering, information and communications technology, communication technology, electrical engineering, and automation.

The proposed PhD program in *ICT Engineering: Software Engineering, Communication Systems, and Engineering Computing* is based on the already adopted strategic research program in Software Technologies for Distributed Systems (DISTECH) at the Department of Computing, Mathematics and Physics, and the prioritized research program in Communication Systems at the Department of Electrical Engineering. ICT and computing has constituted the backbone of the research activities at the faculty over the last decade, in line with all research strategy decisions made by the faculty since 2000. In addition, the proposed PhD program has research links to several other departments at the faculty (e.g. the department of bio- and chemical engineering and the department of mechanical engineering). Furthermore, the researchers involved in the PhD program have research collaboration also with the Faculty of Health and Social Sciences (e.g., in care technology, IT systems for healthcare, and computational medicine), and with the Faculty of Education (e.g., in game-based learning).

## 2 Description of Procedures

NOKUT makes an administrative assessment to ensure that all basic conditions for accreditation are fulfilled as expressed in the Regulation concerning NOKUT's supervision and control of the quality in Norwegian higher education.<sup>1</sup> (Hereafter referred to as the Quality Assurance Regulation on Higher Education.) For applications that have been approved administratively, NOKUT appoints external experts for the evaluation of the application. The external experts have declared that they are legally

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<sup>1</sup> <https://lovdata.no/dokument/SF/forskrift/2013-02-28-237>

competent to perform an independent evaluation, and carry out their assignment in accordance with the mandate for expert assessment passed by NOKUT's board, and in accordance with the requirements for educational quality as determined by the Quality Assurance Regulation on Higher Education.

The expert assessment includes a visit to the institution where the following groups are interviewed: the management of the university college, master students, PhD candidates, academic management, the discipline community, administrative management and potential employers. In addition, the committee inspects the university college's infrastructure. Based on both the written documentation and information from the interviews, the expert committee shall conclude either with a yes or no as to whether the quality of the educational provision complies with the requirements in the Quality Assurance Regulation on Higher Education. NOKUT also requests that the expert committee advise on further improvements of the educational provision. All criteria must be satisfactorily met before NOKUT accredits an educational provision.

If the conclusion reached by the expert committee is negative, the report is sent to the applicant institution, which is then given three weeks to comment. Thereafter NOKUT decides whether the comments should be sent to the committee for additional consideration. The committee is given two weeks to submit the revised assessment. The NOKUT board then reaches a final decision about accreditation.

### **About this document**

The NOKUT evaluation reports show a chronological case history. As described above our procedure makes it possible for the committee to change their conclusion during the evaluation process. This is the case in this report. The final conclusion is in chapter 6. The name of the study program was in the original application *ICT engineering: Software engineering, Communication systems, and Engineering computing*. The committee considered this name unsuitable, and it was changed to *Computer Science: Software Engineering, Sensor Networks and Engineering Computing* by the institution. In this report the original name is used until chapter 5.

## **3 Expert assessment**

This chapter is the expert committee's assessment. The term "we" refers to the expert committee as such.

### **3.1 Summary of the report**

Bergen University College (HiB) has issued an application to NOKUT for accreditation of a PhD program in ICT Engineering: Software Engineering, Communication Systems, and Engineering Computing. The application is dated 29 October 2015. As a part of the accreditation procedure NOKUT relies on an assessment by independent experts, and by February 2016, the present committee was appointed. The committee has had one meeting at NOKUT in Oslo on 2 March 2016, and a site visit with interviews at HiB on 20-21 April 2016. On 7 March, questions from the committee were

forwarded to HiB, and answers and supplementary material was forwarded to the committee on 22 March 2016. The present report presents the findings of the committee regarding the application from HiB. The observations of the committee are only summarized in brief; details must be found in the report. However, the overall conclusion, requirements and recommendations are given in extenso.

The assessment follows the requirements listed in the section on accreditation in the Quality Assurance Regulation on Higher Education 1) Basic prerequisites for accreditation (§ 7-1), 2) Plan for the program (§ 7-2), and 3) Academic environment associated with the program (§ 7-3). Some requirements may be assessed in a fairly objective way, for others the assessment involves balancing different aspects of the information provided. There is obviously a strong interdependence between the different items, and this must be taken into account. The most important aspects of the assessment are briefly mentioned below.

Initially the committee will emphasize that management, staff and students were all very dedicated to making the PhD-program a success. Furthermore, HiB has allocated substantial resources to establish a proper research environment around the PhD-program.

The rationale behind an application for accreditation of a PhD program of study will often be complex. The committee wants to emphasize that such a program must relate to adding new results to scientific knowledge and not just solve different problems at hand in public and private industry. The profile of the proposed program may stand out clearer if this is taken into account in (some of) the revisions suggested below.

With respect to the basic prerequisites, all requirements are (formally) fulfilled. The committee wants to emphasize the very good facilities the present PhD-students are offered: travel grants, library and laboratory facilities, access to supervisors etc. Furthermore HiB seems to be an attractive host institution (jointly with the degree awarding universities), and stakeholders and potential employers underlined the need for candidates from a program like the suggested one. Therefore, it is credible that HiB has the capacity and recruitment potential to maintain a sufficiently large body of PhD-students. Likewise, the number of qualified faculty members allotted to the program is sufficient from a mere quantitative point of view. The faculty members have good research records of accomplishment, and are internationally well connected. However, the committee has some major concerns with the distribution of academic competences between sub-disciplines and with the lack of a coherent strategy for the activities, cf. the remarks in the sequel.

An integral precondition for a PhD-program is that it is to be rooted in an academic environment reflecting as well the curriculum as the research activities of the program. It is beyond discussion that the intersection between software engineering, communications systems, and engineering computing offers some very interesting and challenging research problems of major interest for society. Therefore, the proposal is very timely. However, the term ICT Engineering as well as the qualifying sub-disciplines Software Engineering, Communication Systems, and Engineering Computing comprise areas that are not covered at all by the faculty associated with the proposed program. The faculty members comprise a very diverse group of experiences and interests. Therefore, it is important that the collaboration within the group be sufficiently developed that we may talk about an academic environment and not just a loosely connected collection of researchers. In order to deal with this, it is important that the faculty members behind the proposed study form a coherent research group with a



clear scientific vision for the development of cooperation and research. Furthermore, the program needs a more appropriate name reflecting the aim of study.

Clarifying the scientific content of the program will of course necessitate some adaptations of the wording in different sections of the application, e.g. with respect to learning outcomes. More importantly, these adaptations will in turn expose the parts of the program that needs clarification and strengthening.

In continuation of this, the committee finds it imperative that HiB compiles a “scientific” strategy for the academic environment connected to the proposed program. This should ensure sufficient academic strength and activity in all disciplines included, as well as visions for cross-disciplinary activities. A sustainable academic environment around the topics considered requires additional faculty members, and the necessary resources for this must be allocated to the area.

Therefore - based on the written application with attached documentation elucidated at the on-site interviews - the expert committee finds that the application from HiB does not comply with all the requirements in the Quality Assurance Regulation on Higher Education. Thus, **the committee does not recommend accreditation of the PhD program “ICT Engineering: Software Engineering, Communication Systems and Engineering Computing” at Høgskolen i Bergen.**

Having concluded this, the committee wants to emphasize that - despite the above remarks - it is not necessarily disputed that HiB has a sufficient background for starting a PhD-program in the area right now. Nevertheless, it is important that there are satisfactory answers and solutions to the questions and problems raised. In the conclusion it is stated which demands HiB is required to meet in order to achieve accreditation. In addition, the committee has provided advice for the further development of this study program.

## **3.2 Basic prerequisites for accreditation (§ 7-1)**

### **3.2.1 Requirements assessed by NOKUT**

§ 7-1 (1) The following requirements laid down in the Universities and Colleges Act shall be assessed for accreditation:

- a) Internal regulations and governance
- b) Appeals committee
- c) Learning environment committee
- d) Education plan
- e) Diplomas and Diploma Supplement
- f) Quality assurance system.

### **Assessment**

The regulations for the Doctor of Philosophy Degree at HiB were last amended in 2014, and follow the template provided by the Norwegian Association of Higher Education.

The doctoral diploma is issued to the candidate in accordance with the Act relating to Universities and University Colleges. The diploma supplement follows the standard specified by the Common Student System.

The quality assurance system was adopted by the UC board in 2013 and approved by NOKUT in 2014.

### **Conclusion**

Yes, the criterion is fulfilled.

### **3.2.2 Requirements in applicable regulations and curricula**

§ 7-1 (2) Requirements of applicable regulations and curricula set by the Ministry of Education and Research must be satisfied.

### **Assessment**

According to the ministry's regulations, the minimum requirement for accreditation of studies in the third cycle is 8 FTE's, of which 6 shall be full-time positions, and of which four FTE's are given by professors. It follows from the application that the academic staff contributes to a total of 11 person-years. Out of these person-years, there are 9 professors and 10 associate professors in full-time positions accounting for 10.8 person-years, and one adjunct professor that accounts for the remaining 0.2 person-years. Professor competence constitutes 5.5 person-years while 5.45 person-years are posed by associate professors.

The committee would like to point out that the scientific foundation for the study program is based on three separate research groups, and that the distribution of person-years between the groups is uneven. One group in particular only has one person with professor competence, a fact that puts this group in a very vulnerable position. Moreover, the three groups appear diverse and lack coherence, and the committee is worried about the sustainability of the program in this respect. This concern is further discussed in section 3.4.1.

With respect to recruitment, the ministry's regulations state that the institution must document a capacity and recruitment potential of at least 15 PhD-students to the study program during a 5-year period. The institution must also argue that over a longer period they are able to sustain a PhD group of students with at least 15 members.

In the application, it is stated that there are currently 8 active PhD-students in research groups associated with the program, and that 7 PhD positions are in the process of being filled. They also state that each of the 19 academic staff members with their primary position at HiB will be able to supervise 1-2 PhD-students at any given time.

The institution has a close collaboration with the industry, which makes them well suited for candidates financed by the Industrial PhD scheme. However, most PhD-students enrolled at HiB are financed by internal funds, and the institution would benefit from exploiting external funding more.

## Conclusion

The formal requirements are fulfilled; however, the institution must pay attention to the requirements given in Section 3.4.

The committee finds it credible that HiB has the capacity and recruitment potential to maintain a satisfactory learning environment and a stable program.

Yes, the criterion is fulfilled.

The institution should:

- More actively exploit external funding

### 3.2.3 Recruitment of students

§ 7-1 (3) The recruitment of students to the program should be large enough to enable the institution to establish and maintain a satisfactory learning environment and a stable program.

## Assessment

In the response to the committee's questions to the institution, HiB states that the goal is to have a 50-50 distribution between foreign and Norwegian PhD-students. Close to 20 master students graduate each year from HiB's master program in software engineering and communication systems, which will constitute a natural base for recruitment.

It is stated in the application that 15-20 PhD-students is a realistic number to supervise and fund as a part of the proposed program. This means that 4-6 students will be associated with each of the research fields and some will work on projects that span two or more research fields.

Currently, there is only one PhD-student that works within more than one research field, and HiB lacks a plan for how the research groups will work together towards a common goal. It is also not stated how many of the candidates that will work on joint projects.

The institution performs an interview of all applicants for PhD positions, and if possible, the applicants give a presentation about his/her master project. Currently, all PhD-students within ICT engineering share a common office space, which is located nearby their respective supervisors. They also arrange weekly meetings where the PhD-students present their progress.

## Conclusion

The committee's impression is that HiB has a satisfactory learning environment.

Yes, the criterion is fulfilled.

The institution should:

- Make a plan for how many PhD-students that will work on joint projects and how the involved groups will work together in order to accomplish this.

### **3.3 Plan for the program (§ 7-2)**

#### **3.3.1 Program name**

§ 7-2 (1) The program must have an appropriate title.

##### **Assessment**

The proposed name of the program is “ICT engineering: Software engineering, Communication systems, and Engineering computing”.

The name covers a superarea of the planned content of the proposed PhD study. Both the main title “ICT engineering” and the more specific subtitles “Software engineering” and “Communication systems” are much broader than the area of research at HiB and the area of expertise of the current scientific staff. Furthermore, both the main title and the subtitles are wider than the foreseeable extensions of the staff may be able to cover maintaining a reasonable focus in the research. This discrepancy is most pronounced for the “Communication Systems” area.

The program lacks a Norwegian title. The committee recognizes that “engineering” is a skill, which the planned PhD education at HiB will emphasize and that there is no good direct Norwegian translation for this term. Nevertheless, the program should have a Norwegian and English title covering the same area.

In a search for a revised title, the committee suggests:

- That recognized international nomenclatures are consulted, e.g., the ACM Computing Classification System (CCS)
- With the applied profile for the program expressed during the meetings with the scientific staff and leadership, the software engineering may be considered to be an element in the other two subareas which are more directly related to applications and need not to be included explicitly in the subareas. This would also promote a closer coherence in the research and PhD education in the subareas.
- As food for thought, the committee put forward the following suggestion during the visit: Computer Science: Sensor Networks and Engineering Computing

##### **Conclusion**

No, the criterion is not fulfilled.

The institution must:

- Propose a revised title that more precisely covers the content of the planned PhD study and properly reflects the scientific area of expertise of the staff at HiB.
- Consistent Norwegian and English titles should be proposed.

The institution should:

- Preferably find a title that is shorter and communicates the content better than the originally proposed.

- Find a title that promotes coherence and co-operation between the subareas and research at the groups at HiB.

### 3.3.2 Overall learning outcome

§ 7-2 (2) The program must be described with reference to learning outcomes, cf. National Qualification Framework for Lifelong Learning. The overall learning outcome for each program, defined in knowledge, skills and general competence, shall be described.

Overall learning outcome:

#### **Knowledge**

LO-K1-1. is in the forefront of knowledge in a specialization area rooted in one or more of the fields of software engineering, communication systems, and engineering computing.

LO-K2-1. has comprehensive knowledge on state-of-the-art concepts, methods, and technology platforms within his/her area of specialization.

LO-K3-1. can contribute to the development of scientific knowledge, engineering methods, and software technologies and their application in engineering and society.

#### **Skills**

LO-S1-1. can formulate research hypotheses, plan, and carry out independent theoretically and practically-oriented research work within his/her area of specialization.

LO-S2-1. is able to carry out research work of high international standards that advances the forefront of knowledge and technology within his/her area of specialization.

LO-S3-1. can review research work within his/her area of specialization, relate it to the forefront of knowledge, and assess its applicability for the engineering of ICT and computing solutions.

LO-S3-2. is able to perform research that challenges established concepts, theory, methods and results within engineering of ICT and computing solutions.

#### **General competence**

LO-G1-1. can identify relevant ethical issues pertinent to ICT and computing research and its application in engineering and society.

LO-G1-2. can carry out research work with scholarly integrity and in accordance with the established scientific norms and traditions for research within ICT and computing.

LO-G2-1. can manage and participate in interdisciplinary assignments and projects involving research into, and application of, ICT and computing.

LO-G3-1. can disseminate and publish research results through recognized channels, including scientific workshops, conferences, and journals within ICT and computing.

LO-G4-1. can participate in research discussions and research collaboration internationally on scientific topics within his/her area of specialization.

LO-G5-1. can identify and assess the need for innovation, and initiate and manage innovation projects that apply ICT and computing in engineering and society.

## Assessment

The learning outcome complies with the National Qualification Framework for Lifelong Learning. HiB has chosen to use formulations that are close to the generic template for PhD studies. In the application, two aspects of the planned PhD program at HiB are stressed:

- Engineering of systems.
- An application orientation in the conducted research, i.e. put the technology into operations rather than extending the research frontier within the technology per se.

These intended strengths of the program should be reflected in the planned learning outcomes. Hence, those should be revised to be in accordance with the objective of the studies.

The interviews with the scientific staff left the impression that not all staff was aware of the entire range of the intended outcome of the PhD studies. For instance, it was on one occasion argued that journal publications were not relevant for disseminating research results, in spite of the formulation of LO-G3-1. It seems necessary that the work toward reaching the outcome should be more firmly embedded in the program, cf. recommendations under Sections 3.3.3 Content and structure of program and 3.3.4 Work and teaching methods.

In relation to LO-G2-1, the committee would like to point out that managing interdisciplinary projects, apart from very small ones, is a very demanding task, and that this outcome probably goes beyond those really intended.

In conclusion, the committee finds that the correspondence between the formulated outcomes and the intended ones is insufficient and gives a biased impression.

## Conclusion

No, the criterion is not fulfilled. The formulated learning outcomes are not sufficiently aligned with the intended outcomes, i.e. not properly reflecting the planned content of the proposed PhD study.

The institution must:

- Revise the outcomes so that they properly reflect the scope and revised title of the program, cf. Section 3.3.1.

The institution should:

- Reformulate the learning outcomes so that they emphasize the intended strength of the candidates following the proposed program. For instance, it is strongly advised to include the term “ability to engineer ... systems” as skill. Similarly, the overall description of learning outcomes should de-emphasize outcomes on which the program does not focus.

### 3.3.3 Content and structure of program

§ 7-2 (3) The following conditions shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved:

- a) Content and structure of the program.

#### Assessment

The program is divided into two parts, a) the PhD dissertation and b) a course based training component.

#### Course based training component

Given that the PhD-program will be active, the proposed number of offered PhD courses (ECTS credits offered at the PhD level) is sufficient, but only marginally so. If research interested students take these courses as a part of their master studies and later starts a PhD-study, the program will be short of in-house courses related to the topic. The current PhD candidates working at HiB take their courses at other universities. HiB and UiB already have an exchange of courses at the MSc level. HiB should strengthen the portfolio offered to the students by identifying relevant courses given by other institutions and take steps to make them available to the students, and/or invite external lecturers to give PhD courses at HiB.

The levels of the courses offered are hard to assess from the descriptions offered, but seem satisfactory. The course PHD-ICTENG-7: Engineering computing seems somewhat too narrow in scope. The applications covered could include examples from the work of the entire group.

The only explicitly defined training towards the generic competencies is in the 5 ECTS course PHD-ICTENG-2: Research methodology, research ethics and scientific work practice. This may serve well as an introduction to thesis issues, but it is necessary that continued attention be devoted to these learning outcomes in the rest of the PhD study.

#### PhD dissertation

The work towards the PhD dissertation constitutes 5/6 of the total workload of the PhD study and is the main contributor toward the learning outcomes of the PhD study. This taken into account, the description of the means applied to reach the outcome, i.e. individual supervision and participation in an unquantified number of forums, is insufficient.

The interviews revealed that the scientific staff had the technical outcome of the research as their prime objective, and had put less consideration into how to reach the entire set of learning outcomes. This is a clear indication of the need of a systematic approach. Furthermore, a too strong focus on just the technical outcome, may result in the 'area of specialization' referred to in the learning outcomes being too narrow. This would be avoided by taking a more systematic approach to the learning outcomes as specified.

#### Conclusion

No, the criterion is not fulfilled.

The institution must:

- Define explicitly the type of issues that should be dealt with in the supervision of the PhD-students more extensively / in greater detail than done in the application's Section 2.4.
- Indicate the planned internal forums, their topics/issues and frequency, as well as expected contributions from the candidate in these forums.
- Define guidelines for how candidates should spend time with other institutions, in particular at universities outside Norway.

The institution should:

- Extend the course portfolio by including PhD courses from outside HiB that the candidates can follow at other institutions, or by bringing external lecturers to HiB.
- Ensure that the PhD courses offered at HiB are at PhD level. It should be indicated which of the literature that the candidates is required to have in-depth knowledge of.
- Have a plan for how the items under "The institution must:" should be systematically used to ensure the learning outcomes of the candidates
- Include in the description any other planned activities contributing to the learning outcome.

### 3.3.4 Work and teaching methods

§ 7-2 (4) The following conditions shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved:  
 b) Work and teaching methods.

#### Assessment

The teaching methods proposed for the *Course based training* given at HiB are in accordance with the current practice for PhD courses at most universities.

The teaching related to the *PhD project/dissertation* is based on individual work under supervision. This may lead to supervisors' "ownership" of the PhD candidate and that the candidate gets too little interaction with a broader set of the academic staff and peer candidates. This may hamper the learning outcomes. To counteract this, it is: a) necessary to have at least one co-supervisor per candidate and that all supervisors should form a team rather than giving individual supervision, b) there should be explicitly defined forums where the candidates will meet and interact with a broader set of the academic staff and peer candidates (i.e., the description of such activities given in the application are not sufficiently defined and without obligations.) and c) in addition to the supervision there should be a collective institutional responsibility for the entire staff at the departments/groups to evolve the knowledge, skills and competencies of their PhD candidates.

The application lists how the supervision should lead to the listed learning outcomes. See the assessment of this in Section 3.3.3.

#### Conclusion

No, the criterion is not fulfilled.

The institution must:

- Cf. the items listed in Section 3.3.3
- Establish a scheme for co-supervision and supervisor and candidate teams.



### 3.3.5 Examination and other types of evaluation

§ 7-2 (5) The following conditions shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved:

c) Examination and other types of evaluation

#### Assessment

Assessment of the candidates in the course work that constitute the training part of the program is based on a combination of an oral exam and a written project report in the form of a research article. The project report specifically relates to the skills and general competence of the respective courses. The elective courses are graded as Pass/Fail and all assessment related to the PhD course work will involve two examiners.

The assessment of the dissertation will be based on the PhD thesis, a trial lecture, and a public defence. The thesis will be assessed by an evaluation committee consisting of two external members and one internal member.

During the PhD study, the PhD candidate and the supervisor(s) must submit an annual report to the program committee detailing the progress of the candidate. An annual meeting separately with the candidate and the supervisors is also conducted by the program coordinator. A more comprehensive midway evaluation is conducted in the middle of the PhD project period involving an external assessor.

The committee observes that the project report is the primary means to assess the general competence and skills learning outcomes connected to the theoretical part of the PhD study. While this may be satisfactory, other forms of assessments could be considered in addition to those already described, such as assessing oral paper presentations and paper reviews. It is also unclear from the description how the different elements of the evaluation (oral exam, report) are combined in the overall grading of the coursework. While it is suitable that two examiners are involved in the assessment, it is not mentioned who these examiners will be (e.g., the lecturers of the course, other colleagues at HiB, external examiners, or a combination). The committee is of the opinion that at this level (PhD) it is important to involve external examiners in the assessment.

Regarding the assessment of the PhD dissertation, the HiB regulations for the PhD degree present guidelines for how to handle cases where the assessment committee deems the thesis not worthy for public defence or if there is a non-unanimous committee decision.

In conclusion, overall the committee finds the evaluation types satisfactory. HiB is (strongly) recommended, though, to involve external examiners in assessment of the course work if this is not already the practice. It should also be clarified how the coursework is graded and by whom. Assessing paper presentations and paper reviews may contribute further to a better evaluation of some of the skills. Additional forms of evaluation may contribute to a better fulfilment and assessment of some of the skills of the candidates.

## Conclusion

No, the criterion seems from the available documentation not to be sufficiently fulfilled.

The institution must:

- Clarify how and by whom the grading is done; in particular the use of external examiners and how the different elements of the evaluation (oral exam, report) are combined in the overall grading (pass/fail) of the coursework.

The institution should:

- Consider additional forms of evaluation such as assessing paper presentations and paper reviews to better fulfil and assess some of the learning goals on skills.

### 3.3.6 Relevance of program

§ 7-2 (6) The program must have a clear academic relevance for employment and/or further studies.

## Assessment

As documented in the application, PhD research fellows previously having completed their PhD at HiB within the topic area have obtained positions both in industry and in the university- and university college sector. This includes institutions such as University of Oslo, Zhejiang University, China, and HiB, as well as in industries nationally and abroad.

The interview with potential employers (industry, public institutions) confirms the relevance of the program. The representatives from industry emphasized that HiB's applied research profile is appreciated, as more practical oriented studies are useful for the region. In particular, many of the potential employers highlighted complex data gathering structures and big data as important technology competences for the region. More PhD employments are expected as a natural development. One of the companies, Sensario, stated that they are already working with HiB on sensor networks, involving PhD scholars and that their development is much to the credit of the collaboration with HiB. The representative of Helse Vest IKT stated that they have been working with HiB for years. Two PhDs working on health related topics have already completed their theses and new challenges in health care will be handled by new scholars from this program.

The committee assesses the program topic to be timely and relevant for addressing many societal challenges, and enable candidates to pursue a career in both academia and industry. During the interviews, the representatives of HiB emphasized the value of looking at research needs of smaller companies (SMEs) in the region in order to identify opportunities for research. In this context, the committee would stress that PhD level research should be at an internationally high level and to ensure this it is important also to seek collaboration with industry with research competence and ability to exploit advanced research results. SMEs do often not possess these kinds of competences.

## Conclusion

Yes, the criterion is fulfilled.

The institution should:

- Seek collaboration with industry with research competence and ability to exploit advanced research results in order to better ensure that opportunities with a potential for high quality research at an international level are being identified and thus contributing to higher academic relevance for employment and/or further studies.

### **3.3.7 Links to research, academic- and artistic development**

§ 7-2 (7) The program must have satisfactory links to research and academic and/or artistic development work, adapted to its level, scope and other characteristics.

#### **Assessment**

In the application, it is stated that all PhD candidates will be part of one or more active research groups, and undertake a research project linked to the research competence of the supervisor(s).

During the interview with current PhD-students, the students express that they are well satisfied with the way they are integrated into the research activities of their supervisors. Their PhD topics are typically within the core of the competences of their supervisors.

#### **Conclusion**

Yes, the criterion is fulfilled.

### **3.3.8 Student exchange and internationalization**

§ 7-2 (8) The program must have student exchange and internationalization agreements, adapted to its level, scope and other characteristics.

#### **Assessment**

In the application, it is stated that each candidate will have a stay of 1 to 6 months at an international research institution and collaborate with researchers at the hosting institution. Most supervisors have connections with foreign universities, these being the most likely candidates as host institutions. In this respect, internationalization seems to be in place for most of the groups with the possible exception of the Communication Systems group, which seems to have somewhat weaker connections than the other groups.

Of the five PhD-students the committee met for interview, none of them expressed an intention to go abroad, or stated they had been abroad for a longer period of time, working with researchers at a hosting institution. Rather the committee got the impression that most of them expressed reasons why it was difficult for them to go abroad. Furthermore, the PhD-students stated there were often visitors from other universities giving talks and with whom they could communicate, thus contributing to international contact.

The academic leadership and research group academic staff stated they want to motivate everyone to go abroad, but it depends on the will of the student whether it happens or not. This may be an indication of that not enough attention is given to internationalization.

Adding to this impression, none of the six master students the committee met had been abroad. They were aware of the possibility, but none expressed any desire to take advantage of this opportunity.

The committee believes it is important that HiB place more emphasis on exposing their PhD-students to the international research community. The committee finds it very important for a PhD-student to go abroad for a longer period of time, i.e., at least three months, working with researchers at a hosting institution, getting another perspective on the research, other ideas and other ways of working. This is particularly important for a small institution.

The committee finds it necessary to make it mandatory to have a 3 to 6 months stay at an international research institution and collaborate with researchers at the hosting institution. Only in exceptional cases should a student be exempted from this requirement.

## **Conclusion**

No, the criterion is not fulfilled.

The institution must:

- Make it mandatory to make a 3 to 6 months stay abroad at an international research institution and collaborate with researchers at the institution. Only in exceptional cases should a student be exempted from this requirement.

The institution should:

- Make sure all research groups have sufficient connections with foreign universities acting as hosting institutions for PhD-students.

### **3.3.9 Infrastructure**

§ 7-2 (9) The institution must have facilities, library services, administrative and technical services, ICT resources and working conditions for the students, which are adapted to the program.

## **Assessment**

The program is located in a well-equipped and modern building with all facilities and good administrative support functions. The library services are very good with subscriptions including the most important databases for the program such as ACM DL, IEEE Xplore and SpringerLink.

The lab facilities appears satisfactory including a wireless sensor lab and networking lab (CISCO) for the master- and PhD-students as well as computing facilities for engineering computing and software verification. There are laboratory engineers who will be able to assist the candidates in the practical use of the laboratories.

Each PhD-student is allocated an annual budget of NOK 50.000 for equipment and travel, which the committee finds rather generous. Extra funding is available if additional needs should arise. Each student is also allocated a laptop for personal use.

The office space for PhD-students is currently a single room with 16 PhD-students. A smaller meeting room is available for the PhD-students “next door”. While the office space is nice, it is often pointed out in the scientific community at large that a good student environment must include a space with white board and coffee machine for students to meet during the day to informally discuss their work and exchange ideas and generally socialize.

## **Conclusion**

Yes, the criterion is fulfilled.

HiB should:

- Provide space for PhD-students to meet for informal discussion on scientific matters and exchange of feedback and ideas.

### **3.4 Academic environment associated with the program (§ 7-3)**

#### **3.4.1 The composition, size and competence of the academic environment**

§ 7-3 (1) The composition, size and collective competence of the relevant academic environment must be adapted to the program as described by the program description and also adequate for conducting relevant research and academic or artistic development work.

#### **Assessment**

According to the application, the core faculty connected with the program of study comprises 20 persons delivering in total 11 person-years of which 7.7 is devoted to research and development and 3.3 to teaching and supervision. Half of the faculty members are professors contributing 5.55 person-years and half are associated professors contributing the remaining 5.45 person-years. With the exception of one adjunct professor, all faculty members have their primary position at HiB.

In absolute terms, the size of the computer science environment at HiB is limited. To put the extent of activities in perspective, it can be mentioned that a search in Thomson-Reuters Web of Science listed a total production of 27 papers with 18 citations since 2011. The corresponding figures for UiB are 522 and 1928, i.e. around 20 and 100 times as large.

Table 1. The size, number of publications and citations for the faculty members connected with the program. One person is listed in ‘Engineering computing’ as well as in ‘Applications in engineering’. He appears twice in the head count. His other data are split between the two groups. \*The bibliometric data in ‘Applications in engineering’ relating to the CERN cooperation have been omitted (more than 1000 authors on the papers).

Area of teaching and supervision in program	Head count	Person-years in program			No. of publications		Google Scholar data 2011-	
		Total	T&S	R&D	Level 2	Level 1	Citations	Range h-index
Software engineering	6	3.10	1.00	2.10	18	119	6666	9-27
Wireless sensor networks	3	1.75	0.55	1.20	1	13	175	1-5
Engineering computing	6	3.15	0.95	2.20	22	57	1101	4-13
Appl. in engineering*	6	3.00	0.80	2.20	3*	30*	390*	7-12*
Total	20	11.00	3.30	7.70	44	219	8332	

Obviously, size is not all that matters, but the low numbers for HiB might indicate a lack of robustness in the scientific environment. When evaluating the amount of activities, it is important to have in mind that we are talking about several, not necessarily connected disciplines in computer science. From a relevance point of view, the attempt to formulate a program in the interface between those different disciplines is certainly a strength of the application and reflects needs for candidates in society. However, it is also a weakness in the sense that the number of faculty members needed for supporting such a program is larger than it would have been for a narrower area.

The software engineering subgroup has a strong formal background within model driven software engineering. The group puts a strong emphasis on collaboration with industry. It wants to be a major player in Norway and has an ambition of contributing to change the agenda in Norway in the direction of increased emphasis on developing custom designed software rather than buying existing software products. Crucial to this is growth that necessarily must involve further external funding. The PhD-program is also seen as a means to improve the attractiveness of the group to industrial partners.

A main driver behind the work in the wireless sensor networks subgroup is to have an active role in promoting the use of cyber-physical systems in the regional industry and in the health sector. The group sees itself as a technology provider in cooperation with the other groups. Experienced and skilled engineers are available, but there is a notable lack of research experience in the group. In continuation of the above, the committee finds that the wireless sensor networks subgroup is too limited in size to be sustainable.

The engineering computing subgroup comprises six individuals with a solid background in numerical methods and numerical analysis. They have worked in many areas of science and technology including stochastic modelling and image processing computational medicine – modelling the larynx; solving partial differential equations and computational solid and fluid dynamics, Navier-Stokes equations, flow in porous media; integration of ordinary and partial differential equations on vector spaces and manifolds; finite element methods incl. discrete maximum principle and computational geometry; electromagnetic simulation, modelling of thin films with applications in solar cell

technology, synthesis of nanomaterials. Thus, the group possesses qualifications within a broad range of engineering applications.

The applications in engineering subgroup mainly consists of researchers engaged in the ALICE project at CERN.

The above confirms that the faculty engaged in the proposed PhD program composes a very diverse group of experience and interests. Therefore, it is important that the collaboration within the group is sufficiently developed that we may talk about a group and not just a loosely connected collection of researchers. Without a clear scientific vision for the (development of the) research, a “threat” for any applied PhD-project in computer science with a strong emphasis on cooperation with industry is that too much time may be devoted to work that is closer to consultancy than to provide new scientific insight.

In order to deal with these problems, it is important that the faculty members behind the proposed study form a coherent research group with a well-defined scientific strategy including a clear vision and an action plan for achieving that vision.

With the above remarks, it is not necessarily disputed that HiB has a sufficient background for starting a PhD program in the area right now. Nevertheless, it is important that there are satisfactory answers and solutions to the questions and problems raised. Especially, it is of paramount importance that HiB is committing itself to provide the necessary resources to increase the staff so that important areas will not be dependent on individual faculty members and so that the necessary adaptations of curricula and application areas can be done simultaneously with changing needs in society. Inspired by competencies already present in the group, examples of such adaptations could be to put less emphasis on flow in porous media and larger emphasis on modelling thin films for use in solar cells or other activities in renewable energy, or perhaps expand the activities in data science more relevant to big data etc.

The committee wants to emphasize that the faculty members were very engaged and definitely willing to commit themselves to make the program a success. The PhD-students were likewise very positive, and board and management had shown commitment to invest in the growth of the area. The vision of HiB is that 50 % of faculty members should have research competence. During interviews, it was mentioned that HiB had many qualified applicants for positions in mathematical- and physics related areas. HiB did not see themselves as competitors to NTNU, UiO, and UiB, but found that their applied approach filled a need in Western Norway. This was supported in the meeting with high-level officials from potential employers representing as well public as private enterprises. They all underlined the need for PhD-candidates with applied profiles like those described in the program.

Up-to-date laboratory facilities are obviously an integral part of the relevant academic environment. The committee visited several of those and had others described. The general impression was that the facilities are fully adequate.

## **Conclusion**

No, the criterion is not fulfilled.

The institution must:

- Provide a strategy for the scientific content of the area, including visions for cross-disciplinary activities and an outline of how a long-term continuous update of the program can be secured. There must be an action plan for achieving these goals including plans for recruiting the necessary faculty members within a time span of one-two years.

### 3.4.2 The academic environment's external participation

§ 7-3 (2) The academic environment must actively participate in national and international collaborations and networks relevant for the program.

#### Assessment

The academic environment maintains close links with national and international partners. The application lists more than 20 researchers from abroad that has visited HiB over the last 5 years, and the list of host institutions for faculty members from HiB comprises 30 universities and research institutions abroad.

HiB is partner with 5 European universities (in Paris, Marburg, Madrid, Warsaw, Lisbon) in Erasmus Exchange programs, is a member of the ALICE Experiment group at CERN also enabling exchange of staff and students including PhD-students, and finally there is a Memorandum of Understanding on Higher Education and Research Collaboration with an Indian technical university (in Coimbatore). The committee wants to emphasize that the involvement in the ALICE project provides excellent opportunities for involvement in grid computing and physics data acquisition at the highest level.

The publication records of accomplishment of the faculty members have several joint publications with foreign researchers. Also locally, there is cooperation indicated by the many joint publications with researchers from UiB.

HiB is a member of several relevant, national networks, and the importance of the cooperation with local enterprises and industry was underlined at the interview with representatives for potential employers.

Further details are provided in the internationalization discussion.

#### Conclusion

Yes, the criterion is fulfilled.

### 3.4.3 Academic staff and employment

§ 7-3 (3) At least 50 per cent of the academic FTEs allotted to the program must be staff with their primary employment at the institution. Of these, teachers with competence at the level of at least associate professor must be represented among those who teach the core elements of the program.

For the different cycles, the following additional requirements apply:

- a) For first cycle programs, at least 20 per cent of the collective academic environment must have competence at the level of at least associate professor.



- b) For second cycle programs, at least 10 per cent of the collective academic environment must be professors or docents, and an additional 40 per cent with competence at the level of at least associate professor.
- c) For third cycle programs, requirements are stipulated by Section 3-1 (3) of the Regulations concerning quality assurance and quality development in higher education and tertiary education.

### **Assessment**

The statistics on staff composition given in section 3.4.1 confirm that the formal requirements are fulfilled. It should be mentioned that the qualifications for being promoted to (full) professor are assessed by committees that will always have a foreign member. Sometimes national committees are involved as in e.g. physics. Furthermore, there are full time professors working in each of the four sub-disciplines constituting the area of study.

The main concern of the committee with respect to the size of the academic staff is expressed in section 3.4.1 and regards the fact that not all of the sub-disciplines have a sufficient size to secure a sustainable development of the area.

### **Conclusion**

Yes, the criterion is fulfilled.

However, the institution needs to pay attention to the requirements mentioned in section 3.4.1.

### **3.4.4 The academic environment's research and development work**

§ 7-3 (4) The academic environment must be actively engaged in research, academic and/or artistic development work.

For the different cycles, the following additional requirements apply:

- a) For first cycle programs, the academic environment must have documented results at a level that is satisfactory in relation to the content and level of the program.
- b) For second cycle programs, the academic environment must have documented results at a high international level of quality, with satisfactory academic breadth.
- c) For third cycle programs, the academic environment must have documented results at a high international level of quality with satisfactory academic breadth.

### **Assessment**

The committee has not made a thorough bibliometric analysis of the computer science area at HiB, but the data provided in table 3.4.1 enables computation of some crude measures of bibliometric productivity and impact. The table is primarily based on data provided in the application. Furthermore, the committee requested bibliometric data showing the citation impact of the faculty members as presented by Google Scholar's h-index. The h-index of an author is say 10 if he/she has 10 publications each cited 10 times or more, but not 11 publications cited 11 times or more.

The table gives the summed production of the core staff committed to the program. The numbers have not been adjusted for multiple authorship so they are indicative of the individual activity level, not the

total production of the group. The yearly average number of publications is around 8 level 2 publications and 38 level 1 publications. For a well-established, large environment in science and technology like NTNU, the author fraction at level 2 is around 20%, and with  $8/(8+38)=17\%$  there seem to be a reasonable fraction of publications in high impact media for the faculty connected to the program at HiB. The number of person-years involved in research is (less than) 8, so also the average productivity is at an acceptable level.

The reported h-indices for publications published since 2011 ranges between 1 and 27. It follows that the software engineering subgroup possesses the largest h-indices as well as the largest numbers of citations with a minimum of 9 and a maximum of 28. This is certainly an indication of a strong research activity. The rather low numbers for the wireless sensor networks group is a reflection of the limited resources available combined with the strong focus on making applied projects work.

When evaluating bibliometric statistics, it is of course important to look at not just the total time allocated for research, but also how the time is distributed between individuals. At HiB faculty must apply for research time. Professors are given the same research time allotment as professors at UiB. No professor at HiB has yet lost research time, but some associate professors have. Thus, the conditions for doing research are, at least formally, rather similar to conditions offered at regular universities and therefore the outcome may be assessed in a similar way.

Several types of software tools have been developed – alone or in cooperation with other universities, public institutions and private enterprises. A number of projects in welfare technology and health services involve activities with an innovation focus. In addition, obviously, the work in the ALICE project results in many concrete soft- and hardware solutions to data harvesting and storage.

## Conclusion

The committee finds that there is comprehensive evidence of high quality international research activity at a sufficient thematic breadth. This is seen from

- the range of international publications with good citation impact
- the number of publications at level 2
- the extensive national and international collaboration leading to joint publications
- the many projects involving users and with a clear innovation focus

Thus, yes, the criterion is fulfilled.

However, in ensuring a sustainable development of the field following the requirements given to section 3.4.1 *The composition, size and competence of the academic environment* area, HiB should take the necessary measures to strategy development and staff consolidation.

## 4 Conclusion

Based on the written application with attached documentation elucidated at the on-site interviews, the expert committee concludes the following:

**The committee does not recommend accreditation of the PhD program *ICT Engineering: Software Engineering, Communication Systems and Engineering Computing* at Bergen University College.**

The expert assessment states below which demands the institution is required to meet in order to achieve accreditation. In addition, the committee has provided advice for the further development of this study program.

## **Requirements**

The following requirements listed in the section on accreditation in the Quality Assurance Regulation on Higher Education are not satisfied:

### **§ 7-2 Plan for the program**

- § 7-2 (1) The program must have an appropriate title.
- § 7-2 (2) The program must be described with reference to learning outcomes.
- § 7-2 (3) Content and structure of the program shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.
- § 7-2 (4) Work and teaching methods shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.
- § 7-2 (5) Examination and other types of evaluation shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.
- § 7-2 (8) The program must have student exchange and internationalization agreements, adapted to its level, scope and other characteristics.

### **§ 7-3 The academic environment associated with the program**

- § 7-3 (1) The composition, size and collective competence of the relevant academic environment must be adapted to the program and adequate for conducting relevant R&D work.

## **The following requirements must be satisfied in order to achieve accreditation:**

### **Regarding the plan for the program:**

- HiB must propose a revised title that more precisely covers the content of the planned PhD study and properly reflects the scientific area of expertise of the staff at HiB.
- HiB must ensure that the Norwegian and English titles are consistent.
- HiB must revise the outcomes so that they properly reflect the scope and revised title of the program, cf. Section 3.3.1.
- HiB must define explicitly the type of issues that should be dealt with in the supervision of the PhD-students more extensively / in greater detail than done in the application's Section 2.4.
- HiB must indicate the planned internal forums, their topics/issues and frequency, as well as expected contributions from the candidate in these forums.
- HiB must define guidelines for how candidates should spend time with other institutions, in particular at universities outside Norway.
- HiB must establish a scheme for co-supervision and for ensuring an interaction with a broader set of faculty members and other PhD-students.

- HiB must clarify how and by whom the grading is done; in particular the use of external examiners and how the different elements of the evaluation (oral exam, report) are combined in the overall grading (pass/fail) of the coursework
- HiB must make it compulsory to stay 3 to 6 months abroad at an international research institution and collaborate with researchers at the institution. Only in extraordinary cases should a student be exempted from this requirement.
- HiB must provide a strategy for the scientific content of the area, including visions for cross-disciplinary activities and an outline of how a long-term continuous update of the program can be secured. There must be an action plan for achieving these goals including plans for recruiting the necessary faculty members within a time span of one-two years.

## **Recommendations**

The committee has some further comments to the following requirements listed in the section on accreditation in the Quality Assurance Regulation on Higher Education:

### **§ 7-1 Basic prerequisites for accreditation**

- § 7-1 (2) Requirements of applicable regulations and curricula
- § 7-1 (3) The recruitment of students to the program should be large enough to enable the institution to establish and maintain a satisfactory learning environment and a stable program.

### **§ 7-2 Plan for the program**

- § 7-2 (1) The program must have an appropriate title.
- § 7-2 (2) The program must be described with reference to learning outcomes
- § 7-2 (3) Content and structure of the program shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.
- § 7-2 (5) Examination and other types of evaluation shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved:
- § 7-2 (6) The program must have a clear academic relevance for employment and/or further studies.
- § 7-2 (8) The program must have student exchange and internationalization agreements, adapted to its level, scope and other characteristics
- § 7-2 (9) The institution must have facilities, library services, administrative and technical services, ICT resources and working conditions for the students, which are adapted to the program.

### **§ 7-3 The academic environment associated with the program**

- § 7-3 (3) At least 50 per cent of the faculty must have their primary employment at the institution. This group must include associate or full professors involved in teaching the core elements of the program.
- § 7-3 (4) The academic environment must be actively engaged in research, academic and/or artistic development work.

**The committee offers the following advice to develop the study program further:**

**Regarding the basic prerequisites for accreditation:**

- HiB should more actively exploit external funding.
- HiB should make a plan for how many PhD-students that will work on joint projects and how the involved groups will work together in order to accomplish this.

**Regarding the plan for the program:**

- HiB should preferably find a title that is shorter and communicates the content better than the originally proposed.
- HiB should find a title that promotes coherence and co-operation between the subareas and research at the groups at HiB.
- HiB should reformulate the learning outcomes so that they emphasize the intended strength of the candidates following the proposed program. For instance, it is strongly advised to include the term “ability to engineer ... systems” as skill. Similarly, the overall description of learning outcomes should de-emphasize outcomes on which the program does not focus.
- HiB should extend the course portfolio by including PhD courses from outside HiB that the candidates can follow at other institutions, or by bringing external lecturers to HiB.
- HiB should ensure that the PhD courses offered at HiB are at PhD level. It should be indicated which of the literature that the candidates is required to have in-depth knowledge of.
- HiB should set up a plan for how the items under Requirements D-F should be systematically used to ensure the learning outcomes of the candidates.
- HiB should include any other planned activities contributing to the learning outcome.
- HiB should consider additional forms of evaluation such as assessing paper presentations and paper reviews to better fulfil and assess some of the learning goals on skills.
- HiB should seek collaboration with industry with research competence and ability to exploit advanced research results in order to better ensure that opportunities with a potential for high quality research at an international level are being identified and thus contributing to higher academic relevance for employment and/or further studies.
- HiB should make sure that all research groups have sufficient connections with foreign universities that may be host institutions for PhD-students
- HiB should provide space for PhD-students to meet for informal discussion on scientific matters and exchange of feedback and ideas

**Regarding the academic environment:**

- HiB must pay attention to the requirements mentioned in section 3.4.1 regarding the composition, size and competence of the academic environment.
- In ensuring a sustainable development of the field following the requirements given to section 3.4.1, HiB should take the necessary measures to continued strategic development and staff consolidation.

## 5 Comments from the Institution

Bergen University College submitted their response to the report on 24.06.2016. It had the following attachments:

- Attachment 1: Response (reproduced below)
- Attachment 2: List of advices/recommendations from the committee
- Attachment 3: Vedtak fra høgskolestyret vedr. godkjenning av navneendring og handlingsplan
- Attachment 4: Strategy and action plan in response to the NOKUT draft accreditation report
- Attachment 5: Revised Programme Description
- Attachment 6: Guidelines for internationalization and exchange for PhD candidates

### Response to the draft accreditation report (tilsvar)

**R1: HiB must propose a revised title that more precisely covers the content of the planned PhD study and properly reflects the scientific area of expertise of the staff at HiB.**

We propose the following revised title for the programme of study:

*Computer Science: Software Engineering, Sensor Networks and Engineering Computing*

This title is close to the title suggested by the committee (AR, p.9), but with the explicit inclusion of software engineering. We agree with the committee that narrowing the area of communication systems to that of sensor networks reflects the scientific expertise of the staff. It also reflects the planned future composition and competence of the staff (see R10 response). With this change, Computer Science (as suggested by the committee) describes the overall discipline of the program. This is also consistent with the ACM computing classification system<sup>2</sup> in which the research in model-based software engineering and verification belongs to the category of *software and its engineering* and is founded on theoretical computer science concepts; engineering computing relies on elements from the category of *mathematics of computing*; and grid computing and sensor networks belong to the category of *computer systems organization*. Furthermore, software engineering, sensor networks, and engineering computing can all be considered part of computer science<sup>3</sup> with engineering computing being in the crossroad of scientific computing and computational science.

We explicitly include software engineering in the title for the following main reasons: **(1)** the group in software engineering constitutes a main research strength (AR, p.18-19), and several PhD projects (SA, tables 1.3.1/1.3.2) have had a primary focus on software and its engineering. The area of software engineering is large (AR, p. 9), but model-driven software engineering<sup>4</sup> do encompass a substantial range of software engineering topics (including construction and process), and is important for the developed strategy and action plan (attachment 4); **(2)** the development and

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<sup>2</sup> Available via <http://www.acm.org/about/class/2012>

<sup>3</sup> Peter Denning (2000). Computer Science: The Discipline. In Encyclopedia of Computer Science.

<sup>4</sup> M. Brambilla, J. Cabot, and M. Wimmer: Model-Driven Software Engineering in Practice. Synthesis Lectures on Software Engineering. Morgan Publ., 2012.

application of software technology is a common denominator for the research activities in the programme including sensor networks, engineering computing, and grid computing as also stated by the committee (AR, p.9). We therefore find this term important in order to promote coherence and internal co-operation in the title (A4); **(3)** the courses PHD-CS-3 and PHD-CS-4 are in software engineering making the term important to properly reflect the content and focus of the program; **(4)** more than 80 % of the master's theses in the underlying joint master's degree in software engineering have over the past three years been supervised by HiB faculty members. This makes the inclusion of software engineering important from a recruitment and profession perspective; **(5)** the research group in software engineering is currently involved in several projects and applications involving external funding (including EU-funding) not directly linked to sensor networks and engineering computing. This makes it important for external collaboration and for signaling the engineering focus of the programme. In our view, this justifies software engineering being in the list of research areas that defines the content of the programme (A3).

We have not succeeded in finding a shorter title that in a satisfactory way (from our perspective) properly covers both the scientific expertise of the staff and the content of the program (A3). Still, we find that the proposed title promotes coherence and co-operation (A4) via the three research pillars that forms the programme and provide the basis for cross-disciplinary research (see R10).

**R2: The Norwegian and English titles should be consistent.**

The Norwegian title corresponding to the revised title proposed in R1 is:

*Datavitenskap: Programvareutvikling, sensornettverk og beregningsorientert ingeniørvitenskap*

**R3: HiB must revise the outcomes so they properly reflect the scope and revised title of the program, cf. Section 3.3.1.**

We have revised the overall learning outcomes in the programme description (attachment 5), section 2, to reflect the use of computer science as discipline and the narrower focus on sensor networks. This has prompted also minor changes to the learning outcomes of the mandatory courses PHD-CS-1 and PHD-CS- 2. In addition, we have revised LO-G2-1 (interdisciplinary assignments) removing "manage" as advised (AR, p.11 and A5). LO-G5-1 has been revised to reflect the intended strength on application of technology (AR, p.10 and A5). LO-S2-2 on the *ability to engineer* has been added as strongly advised (AR, p.11 and A5) with emphasis on modelling and validation being common themes in all three research pillars and important elements in the elective courses of the programme.

**R4: HiB must explicitly define the type of issues that should be dealt with in the supervision of the**

**PhD-students in greater detail than is done in the application's Section 2.4.**

Section 5 of the revised programme description (attachment 5) has been expanded to explicitly give information about the type of issues that should be dealt with in the supervision.

**R5: Indicate the planned internal fora, their topics/issues and frequency, as well as the expected contributions from the candidate in these.**

Section 5 of the revised programme description (attachment 5) has been expanded to elaborate on the planned internal fora and expected contributes from the PhD candidates.

**R6: Have guidelines for how candidates should spend time with other institutions, in particular at universities outside Norway.**

We have developed a separate document (attachment 6) intended to aid the PhD candidates in planning their compulsory international research visit (see response to R9).

**R7: The institutions must establish a scheme for co-supervision and for ensuring an interaction with a broader set of faculty members and other PhD-students.**

The regulation for the PhD Degree at HiB (SA, attachment 1.1a, sect. 7.1) states that PhD candidates will have two academic supervisors. This is also reflected in the admission form. The majority (9/15) of the current PhD candidates (SA, table 1.3.1) have two HiB faculty members as supervisors in addition to their formal main supervisor at the degree awarding institutions. We plan to continue the practice of having two HiB faculty members. To make this explicit, we have revised section 5 of the programme description (attachment 5) to reflect this practice. Concerning a scheme for broader interaction with faculty member and other PhD-students, then the group meetings, planned PhD forum, PhD programme seminar, department and faculty seminars, and annual retreat (see R5 response) will expose the PhD students more broadly to faculty members and other PhD-students.

**R8: Clarify how and by whom the grading is done; in particular the use of external examiners and how the different elements of the evaluation (oral exam, report) are combined in the overall grading (pass/fail) of the coursework**

We follow the recommendation of the committee (AR, p12) such that grading in the elective courses is done by a course lecturer and an external examiner. We will also use an external examiner in the mandatory PHD-CS-2 course. This change is reflected in section 7 of the revised programme description (attachment 5). The elective courses PHD-CS-3 to PHD-CS-7 are all graded pass/fail based on a combination of an oral exam and a project report, and the Assessment section of all elective courses in the programme description contains the sentence: *“Each of the two components must result in a pass grade in order to obtain a pass grade for the entire course”*. We now explicitly state this also in the beginning of section 7 of the revised programme description (attachment 5).

**R9: HiB must make it compulsory to stay 3 to 6 months abroad at an international research institution and collaborate with researchers at the institution. Only in extraordinary cases should a student be exempted from this requirement.**

Section 6 of the programme description (attachment 5) and the guidelines for internationalization and exchange for PhD candidates (attachment 6) state that a 3-6 months visit to an international research institution is compulsory. Exemption from this is only possible in extraordinary cases and is subject to approval by the programme committee.

**R10: HiB must provide a strategy for the scientific content of the area, including visions for cross disciplinary activities and an outline of how a long term continuous update of the program can be secured. There must be an action plan for achieving these goals including plans for recruiting the necessary faculty members within a time span of one-two years.**

We have outlined a strategy and action plan (attachment 4) aligned with the revised title of the programme. An important premise has been to combine a long-term scientific foundation based on our strategic research strengths with application areas of high relevance to the faculty and to society (regionally, nationally, and internationally). As a result, the strategy is rooted in the 2016-2020 strategic plan for the faculty and couples the three research pillars of the programme (software engineering, engineering computing, and sensor networks) with the domains of health and care, energy, and ocean. We find that the three core scientific research areas coupled with the thematic application areas yields a good balance between having a programme with a long-term foundation focusing on scientific knowledge (AR, p9), and having applied PhD-projects in areas of high regional and national importance involving industry collaboration (AR, p9). Furthermore, the application areas define an arena for cross-disciplinary activities and research synergy – both within the programme



and towards other engineering disciplines. As detailed in attachment 4, we already have research activities and external funding in the application areas of health and care, ocean, and energy.

To implement this strategy, the board of HiB adopted on June 9, 2016 (attachment 3) an action plan committing resources to recruit four new permanent faculty members and a 3-year post-doctoral fellow. Positions 1 and 2 are in sensor networks with a view towards cyber-physical systems and are defined to make the research group on sensor networks sustainable (AR, p18). Additionally two permanent positions are designed to strengthen the cross-disciplinary activities. The third permanent position focuses on software engineering for embedded systems. Two staff members (Rutle and R. Heldal) already have expertise in this area. Combined with the two new positions in sensor networks, this position will boost collaboration targeting sensor networks and cyber-physical systems in which research on the engineering of software plays an important role. The fourth permanent position concentrates on big data and machine learning (AR, p.19). This position will add a new dimension to the collaboration between software engineering, engineering computing, and sensor networks as the collection, processing, and interpretation of big data sets (e.g. from sensor systems) lies at the crossroad of software engineering and applied mathematics (machine learning). Recognizing the challenges in cross-disciplinary research, the purpose of the 3-year post-doctoral fellow is to provide a full-time researcher dedicated to crossdisciplinary activities and supporting the development of joint research proposal for external funding.

The plan is to advertise the positions both nationally and internationally in the fall of 2016. Recent experience with openings linked to the programme has shown that positions advertised with a clear research focus/profile attract many qualified applicants (both national and international). We therefore find it feasible to fill the positions. To further make the positions attractive, we will associate internally funded PhDs positions to the new faculty positions.

In a letter dated 04.08.16 the Norwegian version of the name was corrected to *Datateknologi: programvareutvikling, beregningsorientert ingeniørvitenskap og sensornettverk*.

## 6 The expert committee's additional evaluation

### 6.1 Evaluation of the comments from the institution

#### § 7-2 (1) The program must have an appropriate title.

*The institutions must:*

- *Propose a revised title that more precisely covers the content of the planned PhD study and properly reflects the scientific area of expertise of the staff at HiB.*
- *Consistent Norwegian and English titles should be proposed.*

## Assessment

During the visit to HiB the committee –as food for thought - put forward the following suggestion for a new title for the program: “Computer Science: Sensor Networks and Engineering Computing”. HiB suggests keeping the original term ‘Software Engineering’ in the title ending up with the English title “*Computer Science: Software Engineering, Sensor Networks and Engineering Computing*”

and – by letter dated 04.08.2016 from rektor Ole Gunnar Søyngen - the Norwegian title

”*Datateknologi: Programvareutvikling, beregningsorientert ingeniørvitenskap og sensornettverk*”.

With the suggested title, the three core research areas in the (new) strategy are explicitly mentioned under the general heading ‘Computer Science’. The Software Engineering group comprises 6 staff members and possesses the strongest bibliometric track record making the wish to include the term in the program title understandable also from a visibility point of view as regards recruitment and external collaboration. Maybe more important are the considerations on making the title reflect content and focus of the program and at the same time also letting the title signal coherence and internal co-operation.

The translation of computer science into Norwegian is not straight forward. Commonly, it is translated into "informatikk" putting more emphasis on the theoretical and non-applied aspects than the broader English computer science. Similar remarks hold for the alternative translation "datavitenskap" earlier suggested by HiB (In letter dated 27.06.2016 the Norwegian title was ”*Datavitenskap: programvareutvikling, beregningsorientert ingeniørvitenskap og sensornettverk*”). The committee finds that the revised Norwegian title using “Datateknologi” presented above in an improved way reflects the engineering aspect of the education, and thus the committee finds that also the Norwegian title is acceptable.

## Conclusion

It is of course always debatable how closely a title for a PhD program should reflect the aims and content of the program. On one side it should not be so broad that it indicates presence of activities not available, on the other side it should be sufficiently broad to allow for a natural, further development of the program. The committee finds that HiB has reached a reasonable compromise between those two extremes. So the criterion is fulfilled.

### § 7-2 (2) The program must be described with reference to learning outcomes.

*The institution must:*

- *Revise the outcomes so that they properly reflect the scope and revised title of the program, cf. Section 3.3.1.*

## Assessment

In “Revised Programme Description. PhD Programme of Study in Computer Science: Software Engineering, Sensor Networks and Engineering Computing” a new set of learning outcomes has been given. The previous heading ICT has been replaced with the generic term computer science, and the narrower focus on sensor networks is reflected in the text. Finally the ability to engineer is introduced as a skill as recommended by the committee.

## **Conclusion**

The committee finds that the new set of learning outcomes reflects scope and title of the program, so the criterion is fulfilled

### **§ 7-2 (3) Content and structure of the program shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.**

*The institutions must:*

- *Define explicitly the type of issues that should be dealt with in the supervision of the PhD-students more extensively /in greater detail than done in the application’s Section 2.4.*
- *Indicate the planned internal fora, their topics/issues and frequency, as well as expected contributions from the candidate in these.*
- *Have guidelines for how candidates should spend time with other institutions, in particular at universities outside Norway.*

## **Assessment**

In the revised program description’s section 5: “Work structure and Teaching Methods” it is given a substantially increased description of the expected contributions from the PhD-students to the everyday life of the parent research group(s). This includes active participation in weekly research seminars, in the regular work meetings of the research group, in the informal PhD Forum, in an annual retreat for the entire scientific staff, and participation in summer/winter schools. Furthermore, PhD-students will regularly attend national and international scientific workshops and conferences.

The work on the research project of the candidate will be based largely on self-study under individual supervision. The PhD-student will typically write several research papers during the course of the study

The PhD studies include a compulsory 3-6 months visit to an international research group. Details on the external stay are given in the new “Guidelines for internationalization and exchange for PhD candidates”.

## **Conclusion**

With the more elaborate description of work structure and teaching methods it has become obvious that HiB will meet what is commonly understood as best practice in PhD supervision, so the criterion is fulfilled.

**§ 7-2 (4) Work and teaching methods shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.**

*The institutions must:*

- *Cf. the items listed in Section 3.3.3*
- *Establish a scheme for co-supervision and supervisor and candidate teams.*

### **Assessment**

The risk of supervisor “ownership” of the PhD candidate causing too little interaction with a broader set of the academic staff and peer candidates was of major concern for the committee since this may hamper the learning outcomes. However, HiB has decided to operate (normally) with two supervisors from HiB. This in addition to the measures described in § 7-2 (3) should address the possible problems with the work and teaching methods.

### **Conclusion**

Thus, the criterion is fulfilled

**§ 7-2 (5) Examination and other types of evaluation shall correspond with and be adapted to the description of the learning outcome so that the learning outcome is achieved.**

*The institutions must:*

- *clarify how and by whom the grading is done; in particular the use of external examiners and how the different elements of the evaluation (oral exam, report) are combined in the overall grading (pass/fail) of the coursework*

### **Assessment**

HiB has decided to follow the recommendation of the committee such that grading in the elective courses is done by a course lecturer and an external examiner. Furthermore an external examiner will be used in the mandatory PHD-CS-2 course. All mandatory and elective courses in the program are graded pass/fail. For courses comprising multiple pass/fail components, a pass grade must be obtained on all components in order to receive a pass grade on the course.

### **Conclusion**

With the above clarification the requirements of the committee are met, and thus the criterion is fulfilled

**§ 7-2 (8) The program must have student exchange and internationalization agreements, adapted to its level, scope and other characteristics.**

*The institutions must:*

- *make it mandatory to make a 3 to 6 months stay abroad at an international research institution and collaborate with researchers at the institution. Only in exceptional cases should a student be exempted from this requirement.*

## **Assessment**

Section 6 of the revised program description and the guidelines for internationalization and exchange for PhD candidates state that a 3-6 months visit to an international research institution is compulsory. Exemption from this is only possible in extraordinary cases and is subject to approval by the program committee.

## **Conclusion**

Thus, the criterion is fulfilled

### **§ 7-3 (1) The composition, size and collective competence of the relevant academic environment must be adapted to the program and adequate for conducting relevant R&D work.**

*The institution must provide a strategy for the scientific content of the area, including visions for cross disciplinary activities and an outline of how a long term continuous update of the program can be secured. There must be an action plan for achieving these goals including plans for recruiting the necessary faculty members within a time span of one-two years.*

## **Assessment**

In response to the draft accreditation report HiB provided: “Computer Science: Software Engineering, Sensor Networks and Engineering Computing. Strategy and action plan in response to the NOKUT draft accreditation report”, a detailed (8 pp.) assessment of the supplemental strategy and action plans. The plan was approved by “Høgskolestyret – Høgskolen i Bergen“ on June 2016.

The size and consequently the collective competences in the research environment supporting the proposed PhD study were of primary concern for the committee. Tightening up the description/definition of the program only diminished the problem marginally. Still some areas are undersized, notably sensor networks. In response to this HiB has decided to allocate a considerable amount of new resources to the area. These include

- An associate professor/professor position in sensor networks
- An associate professor position in sensor networks with emphasis on cyber-physical systems
- An associate professor position in software engineering for networked embedded systems
- An associate professor position in big data and machine learning
- A 3-year post-doctoral position to strengthen the synergy between the research areas

Those positions can be advertised in the fall of 2016. In addition to the positions outlined above, HiB plans to associate two additional positions to the program of study:

- An associate professor with a research profile in sensor networks is expected to be employed at the ‘Department of Electrical Engineering’
- A new position in computing strengthening the collaboration between software engineering, engineering computing, and grid computing and physics data analysis will soon be opened at the ‘Department of Computing, Mathematics, and Physics’

And finally

- An externally funded post-doctoral position focusing on care technology is in the process of being filled

will likewise contribute to the strengthening of the program.

This upgrade enables a considerable strengthening of the sensor network area and in the intersection between sensor networks and the other areas. Besides this, the general level will likewise increase. A cornerstone in the description of the strategy is the emphasis on exploiting the complementary scientific competences in the three core research areas ‘Engineering Computing’, Software Engineering’ and ‘Sensor Networks’ in application-oriented research and development projects of high importance to society with special emphasis on the domains ‘Ocean’, ‘Energy’, and ‘Health & Care’.

The overall vision of the program is further detailed in 7 specific objectives for the period 2016-2020.

## **Conclusion**

With the allocated extra resources and the detailed strategy, the criterion is fulfilled.

## **6.2 Final Conclusion**

Based on the written application with attached documentation elucidated at the on-site interviews, and the response from the institution after the first version of the report the expert committee concludes the following:

**The committee recommends accreditation of the PhD program *Computer Science: Software Engineering, Sensor Networks and Engineering Computing* at Bergen University College.**

## 7 Decision

The PhD program in Computer Science: Software Engineering, Sensor Networks and Engineering Computing at Bergen University College fulfils all criteria for accreditation as detailed in Chapter 7 §§7.1 - 7.3 of *Regulations concerning supervision of the educational quality in higher education (Academic Supervision Regulations)* of 28. February 2013.

The PhD program in Computer Science: Software Engineering, Sensor Networks and Engineering Computing at Bergen University College is accredited.

## 8 Presentation of the expert committee

### **Professor Knut Conradsen, Technical University of Denmark**

Conradsen has a Cand.Scient.-degree in mathematics from the University of Copenhagen and is a professor at the Department of Applied Mathematics and Computer Science at the Technical University of Denmark (DTU) in the field of image analysis. Conradsen has extensive experience with academic leadership from roles as department head and prorector at DTU. His research focus is the development and adaptation of methods and theory for solving data analysis problems within a wide field of applications. Conradsen has wide experience as a teacher and supervisor, having supervised both master end PhD-students. He can document considerable experience with academic committee roles. Conradsen is the head of committee.

### **Professor Bjarne E. Helvik, Norwegian University of Science and Technology**

Helvik is Vice Dean of research at the Faculty of Information Technology, Mathematics and Electrical Engineering at NTNU, and has responsibility for the six PhD-programs at the faculty. He has a siv.ing. degree from NTH 1975 and a Dr. Techn. from the same school in 1982. His research field is dependability modelling of computer and communication systems. Helvik has earlier held a position as senior researcher at SINTEF.

### **Professor Frank Eliassen, University of Oslo**

Eliassen is the group leader of the research group Networks and Distributed Systems at the Department of Informatics at the University of Oslo. He has experience from EU and NFR-projects, and was head of the program board for the NFR program IKT2010. Eliassen has supervised more than 20 PhD-students. He has more than 170 publications in international journals, conferences and workshops. He is formerly head of the department of Computer Science and Dean of the Faculty of Science and Technology at The Arctic University of Norway.

### **Ph.d.-student Henrik Finsberg, Simula Research Laboratory**

Finsberg was hired as a Doctoral Research Fellow at Simula Research Laboratory in the Center for Cardiological Innovation on 01.10.2015, and is working on patient-specific heart modelling. He has a double master degree from NTNU in Trondheim and DTU in Copenhagen in Applied and Engineering Mathematics. Aside from his studies, Finsberg has had positions such as leader of the student organization for physics and mathematics at NTNU and a leadership role in ENT3R NTNU.

## 9 Documentation

15/695-1 Høgskolen i Bergen - søknad om akkreditering av ph.d.-studium ICT Engineering: Software Engineering, Communication Systems and Engineering Computing

16/00149-11 Tilsvar på utkast til sakkyndig rapport - Høgskolen i Bergen - Akkreditering av studiet ICT Engineering

16/00149-12 Korrigering av norsk namn på ph.d.-studium - Høgskolen i Bergen - Akkreditering av studiet ICT Engineering