



UNIVERSITY
OF SKÖVDE



Assessment of Research and Collaboration 2013



UNIVERSITY OF SKÖVDE

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DNR HS 2012/459-60

How to cite this report:

University of Skövde. (2013). *Assessment of Research and Collaboration 2013 (ARC13)*.
Skövde: University of Skövde

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Preface

The assessment of research and co-production 2013 (ARC13) is the first assessment of research ever done at the University of Skövde. The overall aim is to provide means to strengthen the quality of the scientific activities at the university by offering reliable background material for future strategic decisions. Several old universities have performed assessments of research. ARC13 is, however, the first time an assessment takes into account also co-production. Co-production is defined as production of research together with outside stakeholders. In a way co-production involves taking care of ideas generated in academic research transforming these into useful activities in industry and society.

The funding of the ARC13 is a joint effort between the Knowledge foundation (KK-foundation) and the University. Three of the research specializations in ARC13 are part of a large program, KK-environment, financed by the Knowledge foundation. The Knowledge foundation supports research at the new universities in Sweden, but only research that is done in co-production. The mission of the Knowledge foundation is to help the new universities of Sweden to create an international competitive research environment. The ARC13 is performed at three new universities at the same time, besides University of Skövde, these are done at the University of Halmstad and the Mid Sweden University.

The result from ARC13 will enable the University to formulate strategic goals and the researchers to formulate plans for future research. The assessment has been done by assessing performance and prospects of the Unit of Assessment as a whole and not the individual scientists.

Besides giving examples of strength and internationally high quality research, the assessment identifies emerging areas which have the potential to grow strong. Good examples on linking research and innovation will prove valuable when communicating with the surrounding society. A set of recommendations given by the expert panel members will identify needs for support for faculty members. A very positive side-effect is the potential to strengthen the international networks through the international expert members of the panels. Success stories in research are another valuable part of the ARC13. This may prove useful in the future to gain visibility to potential research financing bodies as well as attracting and keeping faculty and administrative staff and enroll new students.

Sigbritt Karlsson
Vice-chancellor

1. Introduction to University of Skövde

University of Skövde celebrates its 30th anniversary this year, 2013. Thus it is a young university which originally started with teaching and education as the primary tasks. Higher education in Sweden is based on academic or artistic footing and proven experience. The academic footing is closely linked to scientific basis. That means that offering teaching and education at first, second and third level (Bachelor, 1- and 2-year master, Ph.D. level) requires access to research in the subjects in order to be successful. The University of Skövde provides an effective learning environment which thrives at every level. The relationship between research and teaching/education is 20:80 based on resources.

2013, the University of Skövde has around 10 000 students enrolled in programs and courses. The number of staff, administrative and faculty, is around 500. The major part of the governmental funding received is directed to teaching and education. In comparison to old universities, the funding directed to research is small, 2012 it was around 39 MSEK. The number of full professors is 17 and together with c:a 120 associate and assistant professors these constitute the faculty that is available for research. Presently around 60 students are engaged in Ph.D. studies.

The vision of the university is to be a leading and excellent centre of teaching, education and research in Sweden within five research specializations. These are Informatics, Virtual Systems, Systems Biology, Enterprises for the Future and Health and Well-being. The most mature specialization is in Informatics, where the University has the right to award degrees at first, second and third level. Teaching and education is provided in the areas belonging to the research specialization. General degrees at bachelor and 1-and 2-year masters are combined with professional education and training in nursing, engineering and vocational teachers studies.

The privilege to award Ph.D. degree in Informatics was given in 2010. The vision is to be able to award Ph.D. degrees in all of the five research specializations. This is a long-term commitment requiring quality and volume in teaching and education as well as in research. Before being granted the right to award Ph.D. degrees in all five specializations research education is done in collaboration with universities that have the right to award degrees at the third level in these particular areas.

The governmental resources given to the University is mostly directed to teaching and education. The relatively low amount of governmental funding is matched by funding received in competition by an active and engaged faculty. The balance between funding won in competition and governmental funding is about 60:40. This is a very good balance showing that research taking place at University of Skövde is attractive to various financing bodies.

University of Skövde has a vision that involves being successful in combining education, research and innovation. That means that there is a clear focus on demand driven and applied research. This does not mean that basic research is avoided. A good balance between basic and applied research is necessary in order to formulate new research questions. The demand driven research means that co-operation with the surrounding society is an integrated part of the research and education.

An active collaboration is the one with the Gothia Science Park, this is maybe the best example in Sweden in bridging academia and innovation. The research and innovation environment, University of Skövde and Gothia Science Park, is directed to the students and the faculty. It involves taking care of ideas generated by the students supporting their ideas developing into business. But is also involves supporting the researchers to transform classical research results to emerging innovations.

An important task for a university outside the big cities in Sweden is to be able to offer education and research directed to the regional environment. The university takes this responsibility, but equally important is to be national and internationally competitive. Over the years the university has used the international arena in order to *e.g.* gain access to education at Ph.D. level, several of the present faculty members have gained their Ph.D. degree at an international university.

Within the vision of the University lies internationalisation in teaching and education and in research. Attractive education programs means that students choose to come to Skövde bringing international perspective also into working life regionally. Internationalisation is a continuous effort involving applying and receiving *e.g.* EU-funding for research. In relation to the overall resources for research, the University of Skövde is very successful in attracting EU-funding for research.

There has been a clear need to focus education and research at the University based on the relatively low governmental funding directed to research. The five research specializations have crystallized over the years. Early on the informatics, engineering and systems biology areas emerged. About 15 years ago the area of nursing was added to the university, this is an important part of the research now grouped within the specialization of Health and well-being. Only in 2011 the research specialization of Enterprises for the future was formulated. This in turn has enabled the formulation of clear missions and goals for the selected research specializations. It has created a research environment that has the potential to give quality and volume. In comparison to old university the faculty has the responsibility to both teaching/education and research. This means that in general all faculty staff has a large responsibility for teaching and education.

The University is using given resources very effectively and figures presented nationally shows that the allocated funding per publications is the lowest in Sweden. University of Skövde has proven that with a relatively low amount of funding high quality research is possible at a young university, as expressed by the expert panels in this evaluation. In addition, recent figures suggest that a young university such as Skövde may compete among the old universities in giving high quality in teaching and education. Creating a highly specialized university, attracting and retaining an engaged and active staff combined with clear visions are all necessary parts in order to reach and keep high quality in teaching, education and research.

2. An overview of Swedish Universities

2.1. Introduction

Sweden has 34 state universities and university colleges, which varies tremendously in size and rights to issue degrees (Table 1). In addition there are some universities that are private or run as foundations, most of them being rather small. Three of the larger foundation universities were established by the state in order to increase the variety of organizational forms of Swedish universities (these are included in Table 1). By looking at the state funding and rights to issue degrees, one can divide the universities into four categories:

2.2. The “old” universities

This is a group of the oldest Swedish universities, from Uppsala University, established in 1477, to Linköping University established in 1975. Besides their age, these universities stand out by their large amounts of funding for research by the government (750 – 1 896 million SEK; with one exception), and their high ratio of research funding in relation to funding for education (0.6 - 2.2). They have full rights to issue general academic degrees. It is also among these universities we find most of the medical schools for the training of physicians. Many of them also train civil engineers.

2.3. The “new” universities

Among these universities, Luleå University of Technology is the one which has had its university rights the longest, since 1997. As full universities they have full rights to issue degrees from bachelor to doctor. Many of them are the result of merged university colleges which were established in 1971-1977. As a consequence of the earned status as full universities, the research funding is more substantial compared to those that still are regional universities (see below). The state funding for research ranges from 195 to 340 million SEK, and the ratio of research / education funding ranges from 0.29 – 0.56.

2.4. The regional universities

These universities were, like the new universities, established as university colleges in the 1970's and the 1980's as part of the governmental strategy to reach the goal of 50 % of the Swedish population earning a bachelor degree or similar. The state funding to these universities increased in the late 1980's and the 1990's, mostly in funding for education. Today, the amount of state funding is between 20 and 105 million SEK, and the ratio of research / education state funding is 0.11 – 0.32. In 2010, the government opened up for regional universities to apply for rights to award doctoral degrees in specialized fields. The universities could then define their own fields, which were evaluated after application. This has stimulated the universities to develop research environments of academics competent to supervise PhD students. Most of the regional universities have PhD rights in at least one and even up to eight fields of specialization. Four of these universities, Malmö University, Jönköping University, Blekinge Institute of Technology and Mälardalen University had PhD rights before 2010. During this period, universities without their own rights employed PhD students but registered them at universities with PhD rights.

Sometimes also the main supervisor was locally employed and appointed by the host university.

2.5. The university colleges

The university colleges are fairly small universities with research funding from 4 to 23 million SEK. None of them have the right to award doctoral degrees. They are situated in Stockholm, and except for the National Defence College they are all schools of the arts.

2.6. The Bologna system in Swedish higher education

In the Swedish system, universities can issue both 1- and 2-year master degrees. This is a result of the Bologna process in 2007, when Swedish higher education went from two levels to three levels. Prior to 2007 the basic level had a three year bachelor degree or alternatively a four year “magister” degree. On top of that was four years of PhD studies. At the Bologna harmonization, the intermediate master level was introduced with a 1-year master and 2-year master degree. Rights to issue the “magister” were automatically transformed to give the 1-year master degree, which in Swedish kept the name of “magister”.

Most universities have full rights to issue 1-year master degrees, whereas the rights of the 2-year master degrees are linked to the academic research competence in specialized fields. It was natural for many universities to start applying for 2-year master rights, before they applied for PhD rights in the same fields. Universities with PhD rights automatically got the rights for the 2-year master. For this reason, the PhD rights are usually a subset of the 2-year master rights.

Table 1. An overview of Swedish Universities and the funding they receive from the state for education and research, including the ratio of the research / the education. The universities are sorted in order of decreasing amount of funding for research within each group by. For each university the rights to issue doctoral degrees, 1- and 2-year master degrees, and bachelor degrees are marked with symbols (see footnotes). In addition, the rights to issue medical degrees for physicians, civil engineer, nursing and teaching at elementary, middle or high school are marked by X-symbols. The funding is taken from the governmental budget (Prop. 2012/13:1), and the rights to issue degrees are from Swedish Higher Education Authority's (<http://english.uk-ambetet.se>) database.

University	Education		Research (tSEK)	Ratio R/E	Rights to issue degrees ¹			Rights to issue some professional degrees				
	(tSEK)	Ph D			2-yr Master	1-yr Master	Bachelo r	Physicia n	Civil engineering	Nursin g	Teaching 2	
"Old" Universities												
Lund University	1 788 031	1 896 253	1.06		X+A	X+A	X+A	X	X	X	X	X
Uppsala University	1 362 345	1 841 565	1.35		X	X	X	X	X	X	X	X
Stockholm University	1 544 810	1 447 906	0.94		X	X	X				X	X
Göteborg University	1 826 949	1 376 929	0.75		X+A	X+A	X+A	X	X	X	X	X
Karolinska Institute	595 639	1 338 788	2.25		X	X	X	X		X		
Royal Institute of Technology	989 680	1 302 980	1.32		X	X	X	X		X		X
Umeå University	1 208 795	992 689	0.82		X	X+A	X+A	X	X	X	X	X
Chalmers University ³	768 282	769 049	1.00		X	X	X	X	X	X	X	X
Linköping University	1 317 794	750 324	0.57		X	X	X	X	X	X	X	X
Stockholm School of Economics ³	74 433				X	X	X					
Swedish University of Agricultural Sciences	1 634 369				X	X	X					
"New" Universities												
Luleå University of Technology	611 026	340 444	0.56		X	X	X		X	X	X	X
Linnaeus University	953 521	275 823	0.29		X	X	X			X	X	X
Örebro University	653 065	216 478	0.33		X	X	X	X	X+A		X	X
Mid Sweden University	509 234	198 719	0.39		X	X	X		X	X	X	X
Karlstad University	561 593	195 257	0.35		X	X	X		X	X	X	X

¹ X= general rights (except in the arts), A= in the arts, T= in technology, N= in the sciences, S= in social sciences, M= in medicine, Numbers = number of rights in more specialized fields
² Teachers examinations rights may be limited to subject and school level
³ Non-governmental Universities

Table 1. continued

University	Education n (t SEK)	Research h (t SEK)	Ratio R/E	Rights to issue degrees ¹				Rights to issue some professional degrees			
				Ph D	2-yr Master	1-yr Master	Bachelor r	Physicia n	Civil engineering	Nursin g	Teaching 2
"Regional" Universities											
Malmö University	796 138	105 214	0.13	8	M+9	X	X			X	X
Jönköping University ³	502 972	84 655	0.17	S+1	S+3	X	X			X	X
Blekinge Institute of Technology	259 698	83 122	0.32	2	T	X	X		X	X	
University of Gävle	407 989	82 229	0.20	2	4	X	X			X	X
Mälardalen University	555 030	78 135	0.14	6	T+1	X	X			X	X
University of Borås	429 742	54 619	0.13	3	4	X	X			X	X
Dalarna University	386 128	53 996	0.14	1	2	X	X			X	X
Halmstad University	352 998	53 955	0.15	3	3	X	X			X	X
Kristianstad University	342 067	45 739	0.13		2	X	X			X	X
Södertörn University ⁴	363 505	40 504	0.11	4	12	X	X				X
University of Skövde	306 798	39 767	0.13	1	2	X	X			X	X
University West	349 121	39 190	0.11	2	4	X	X			X	X
The Swedish School of Sport and Health Sciences	86 895	25 202	0.29	1	1	1	X				X
Gotland University ⁵	124 157	20 848	0.17			X	X				
University Colleges											
Stockholm Academy of Dramatic Arts	112 037	23 640	0.21		A	A+1	X+A				
National Defence College	23 053	8 566	0.37			2	X				
Royal College of Music	119 275	7 647	0.06		A+1	A+3	X+A				X
University College of Arts, Crafts and Design	149 024	7 557	0.05		A	A+11	X+A				X
University of Dance and Circus	56 534	5 637	0.10		A	A	X+A				X
University College of Opera Stockholm	17 388	4 809	0.28		A	1	X+A				
Royal Institute of Art	59 295	4 326	0.07		A	2	X+A				

⁴ Lifts an additional 175 000 t SEK (appx) annually from their own foundation established by the state

⁵ Merges with Uppsala University 1 Jul 2013

3. Faculty Boards at the University of Skövde

The University of Skövde has, according to the Swedish Higher Education Act (4 §), its own responsibility for ensuring high quality in education and research.

Two faculty boards were established in 2011:

- The Faculty Board for Informatics, Engineering and Natural Sciences, and
- The Faculty Board for Educational, Health and Social Sciences.

The faculty boards have been given the overall responsibility for ensuring the quality of research and education within their respective academic fields. Their main responsibilities fall into three main categories:

- developing local rules and regulations for establishing and carrying out education and research,
- establishing quality criteria for education and research,
- evaluating education and research at the local level, and
- initiating measures to deal with specific quality problems.

From January, 2014 the University will have one joint faculty board.

3.1. The Faculty Board for Informatics, Engineering and Natural Sciences

The research that falls under the responsibility of this faculty board relates to the Informatics Research Centre, The Virtual Systems Research Centre and the Systems Biology Research Centre. These centres have been formally established by the University Board.

All three centres are involved in a 10-year research program (KK environment). The program is co-funded by the Swedish Knowledge Foundation, companies and the University. It is aimed to strategically strengthen the research environment at the University. Within this program the responsibility of the faculty board is to ensure the scientific quality of research activities carried out in the program. Among the responsibilities of the faculty board is to assess applications for funding and evaluate the quality of scientific results.

The University has been granted the right to issue PhD degrees in Informatics. The faculty board is, therefore, responsible for ensuring the quality of PhD education in this area.

3.2. The Faculty Board Educational, Health and Social Sciences

The research that falls under the responsibility of this faculty board relates to the research specializations of Health and Wellbeing and Enterprises of the Future, which have not yet been formally established as research centres by the University Board.

To support the development of these research specializations toward becoming established as research centres, the faculty board has during its term launched a set of key indicators for research related activities. The 29 indicators are divided into six main categories pertaining to various kinds of research related activities: publications, professional and editorial activities, research grant proposals, participation at national and international scholarly conferences, contribution to doctoral programs, and other scientific activities. The indicators are collected subject-wise once a year, which makes it possible to quantitatively demonstrate different types of activities. The principal aim is to, over time, highlight strengths and to discover weaknesses that need to be addressed.

4. Designing the framework of the Assessment of Research and Coproduction 2013

4.1 Background and guiding principles

The Assessment of Research and Coproduction 2013 (ARC13) was a joint initiative from three Swedish Universities, Halmstad University, Mid Sweden University and Skövde University, with the ambition to develop a framework suitable for assessing research, collaboration and coproduction in research at all three universities.

The process was initiated by the vice Chancellors of the three universities, with the objective not only to evaluate the quality of research and coproduction by international standards, but also to support the strategic development of the research. A steering group with representatives from the three universities was accountable for setting up the framework of the assessment.

The assessment process consisted of four steps: (i) identifying quantitative indicators and qualitative descriptors as part of an evaluation package; (ii) collecting data of the indicators; (iii) a self-assessment made by the UoA; and (iv) a peer review process conducted by international experts.

The national steering group met several times to define the terms of reference for the process and guiding principles for developing criteria for quality in research and coproduction. All through this process, experiences from previous research assessments done by the Royal Institute of Technology (KTH) were discussed with Peta Sjölander (project coordinator of the evaluation at KTH). Reports from other universities in Sweden, which had already undertaken similar research assessments were also used as background material (Lund University, Uppsala University, Sweden University of Agriculture, and Örebro University), together with indicators for coproduction developed by VINNOVA and the report of the Swedish Research Council on citations (VR report 5:2012). Further, the Research Assessment Exercise and the Research Excellence Framework made in the United Kingdom provided an input for the working groups to identify indicators.

Three working groups were created with the assignment to develop parts of the evaluation package: (i) assessment of the research; (ii) assessment of the coproduction; and (iii) the bibliometry. Each university had their own local group and the national steering group coordinated the three groups. However, for developing bibliometric indicators, there was only one working group with representatives from all three universities.

The local working groups from all three universities were responsible for the dialogue with researchers at their home universities. The local working groups consisted of senior researchers representing the diverse disciplines at their University, thereby having both the mandate and competence to develop a framework to guide the research environments in completing the assessment. The coordinators of all working groups met regularly to share experiences and ideas in order to develop the evaluation package. Some aspects were highlighted as particularly important to guide the development. For example, the evaluation package should:

- Drive the quality of research and coproduction within the different Units of Assessment (UoAs).
- Measure the current status of research and coproduction.
- Identify areas of potential and options for strategic development.
- Result in concrete recommendations for future development.

As such, ARC13 is meant to provide means to strengthen the quality of the scientific activities at the three universities by offering reliable background material for the decision-making process related to future strategies. The reports from the UoAs (written and oral) on their own work should, together with the bibliometric study, constitute the basic input for the evaluation.

4.2 Designing the evaluation package and terms of references

As ARC13 addresses diverse research areas within the university there were several discussions centred on identifying indicators that were applicable across disciplines. Extensive discussions on defining quality led to the choice of indicators for measuring both performance output as well as process, thus including a self-assessment, e.g., the aspect of potential for renewal. The working group concluded that an evaluation of future plans and strategies was also important.

Furthermore, ARC13 set out to include indicators evaluating coproduction. As cooperation and coproduction with society are important aspects for quality and impact, these aspects were included in the evaluation package.

4.3 Data collection

When the package of common quantitative indicators had been developed, the collection of data started at each university. It was agreed that the individual university could add indicators reflecting its specific needs, but that there would be a common base package.

4.4 Self-assessment

Every UoA had one or two coordinators, who communicated with UoA members and collected input to the preparation of the Evaluation Package. The coordinators led the writing of the self-assessment, and prepared the program for the panel visits with the UoA. While a cumbersome process, it provided focus and initiated quality-driving activities in a formative assessment manner. Analysing the status and reflecting on how to go forward, thus proved to be an important part of the process and in itself a way to develop the research units.

4.5 Expert reviews

A panel predominantly consisting of foreign experts (in some cases exclusively from other countries) was engaged for the commission to review the research and coproduction for each UoA. The number of panel members (for University of Skövde) ranged between three and five, with five members as the most common number. Most experts were from Europe, and were chosen for their experience in evaluating research and/or coproduction at an

international level. At least one member in each panel was selected to evaluate coproduction.

The panels received the self-assessment of their UoA (including the indicators) at least two months ahead of the planned visit at the University.

The expert panels met with the UoA during a visit at the university that lasted for five days. During these days, the panels attended research presentations and visited different areas for research such as laboratories. In several instances, the panels met with UoA partners presenting the joint coproduction of research and how the research results were integrated in the activity of the company. Some panels even visited companies or other non-academic collaboration partners.

In order to provide criteria for assessment of the UoAs, guiding principles for the panels had been developed (Appendix 2: Instructions to experts including grading scale). The expert panels were asked to assess the quality of research of the UoA in an international perspective. In particular, the panels were asked to identify strong research activities and potentially interesting opportunities for renewal. It is important to note that the evaluation did not intend to compare different departments and disciplines with each other. Instead, it aimed at probing the standing in national and international perspectives, reflecting the quality and potential for renewal of each UoA compared to that of other universities involved in the same research field. The experts were asked to grade seven aspects of the research according to a pre-defined scale (Appendix 2: Instructions to the experts including grading scale).

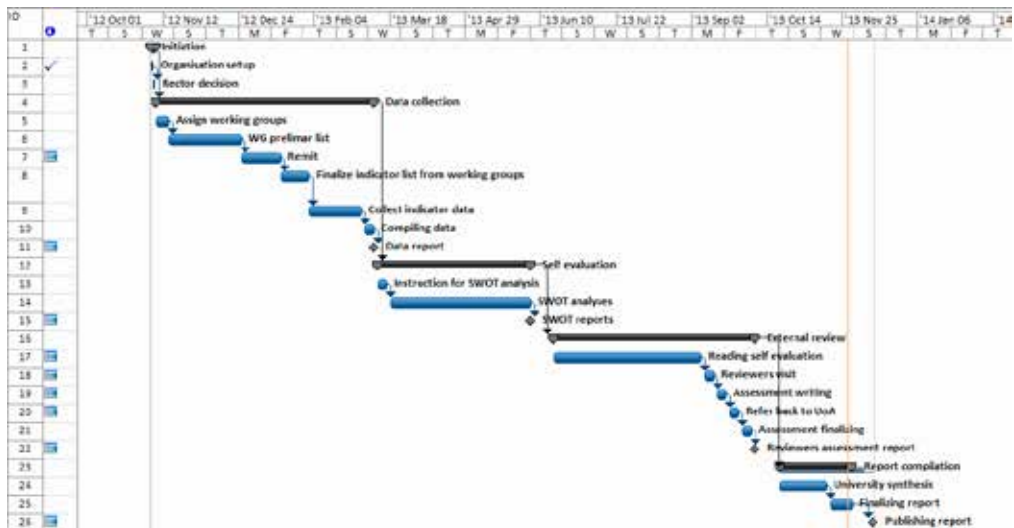


Figure. Timeline for the ARC13 project. Grey bars indicate work packages and blue bars the tasks within work packages. Diamonds indicate deliverables.



The panel members

Back row from the left: Lars Dencik, Moyra McDill, Diane H Sonnenwald, Kari Lilja, Carmen Molina-Paris, Anna Saran

3rd row: Katri Vehvilainen Julkunen, Jerome Bickenbach, Nancy Russo, Erik Proper, Hans-Georg Stork, Parvez Haris

2nd row: Christian Helms Jørgensen, Viggo Tvergaard, Heiner Bubb, Peter De Ruiter, Julian Leslie, Pekka Abrahamsson, Costis Kompis

Front row: Celeste Wilderom, Siau Ching Lenny Koh



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Assessment report

Enterprises for the Future

Kari Lilja, Aalto University, Finland

Siau Ching Lenny Koh, Sheffield University, UK

Celeste Wilderom, University of Twente, Netherlands

Preface

University of Skövde has had three research centres that have specialized in the following areas of research: Information Technology, Virtual Systems and Systems Biology. The centres have jointly developed a unique research programme called “Information Fusion”. In April 2011, Vice-Chancellor of the University, Sigbritt Karlsson, asked Professor Stefan Tengblad to investigate the possibility and desirability to establish a new research centre within the disciplinary area of business and management studies. A parallel initiative for setting up another centre within the social science field was launched with a specialization in health and well-being.

Within the business and management studies field, distinct research groups and potential leaders for them were identified and the centre got a tentative name: Enterprises for the Future. This reflects the main research areas and priorities of the groups which defined their focus areas to be the following:

- Internationalization processes (Group 1)
- Strategic and entrepreneurial processes (Group 2)
- Leadership and process development (Group 3)

At the end of 2011, the University decided to include this centre initiative to its development plan and at the end of 2012 it was also included into the research evaluation exercise labeled ARC13. Based on this decision, Professor Tengblad and the leaders of the above mentioned Research Groups prepared a Self-Assessment Report which has served as background material for this evaluation report. The report is structured according to the template provided by the Board of Assessment of the University.

1. General Assessment of the Research Centre “Enterprises for the Future”

1. The Research Centre has been skillful in detecting and defining **relevant and focused thematic areas** and established research groups, using a **combination of good Research Centre leadership and a bottom-up approach**.
2. The research groups have been successful in gaining **external research funds**, producing **publications** to international journals and initiating and maintaining **linkages to stakeholders** in order to have access to data and be able to participate in coproduction.
3. As to the quality of research, there are a handful of senior researchers who are **visible in the international scientific community and nationally leading** in their fields. Those research leaders are capable, in our view, to lead and mentor junior colleagues towards the international frontline.
4. The Research Centre has **high research productivity**, even though they are mainly tasked with teaching and their total FTE for research is very low.

5. The members of the Centre have **strong collaboration internally** among themselves and a considerable amount of them work with colleagues at the national level. At this point, few of them have strong collaborations with international colleagues.
6. Most of the **coproduction** has been done at the individual **researcher level** and has not yet been institutionalized with stakeholders, except in few research areas.
7. There is evidence of the **impact of research done for society**, especially in the **regional** context.
8. The leading researchers in the Centre have a **clear mission** and a desire to improve the quality of research at the Research Group level but the steps to be taken to implement this international-upgrade mission are still in the making. This is understandable because there are many routes to gain attention in scientific communities and increase the productivity and impact of research. These routes may also differ between the Research Groups. Some groups may emphasize increased rigor in **mainstream research**, link themselves internationally with leading similar research groups and gain quickly high productivity and impact. Some groups may opt for relevance and engage themselves with a **multidisciplinary approach** that in the long run turns to a cross-disciplinary tradition in the international scientific community (like the institutionalization of Organization Studies). Some groups may detect distinct **emerging niches** for research based, for instance, on technological breakthroughs and for this reason **path-breaking findings** from a global point of view can be made. The trigger to such findings can be, for instance, the access to unique contexts where **co-production is done with leading stakeholders, innovative multi-level research designs** can be constructed, **new epistemic approaches are linked with new research methodologies or data banks** are accumulated from longstanding research collaboration.

2. Quality of research

The Centre's overall current research output quality is at a **national standing** (level 1). This is 'measured' by the publication outputs, and specifically the journal outlets chosen according to the Norwegian journal ranking system. Aligning this to other well established journal ranking systems such as the Association of Business School (ABS) list or the Australia Business Deans Council (rankings available online), the overall quality of the research output is at 2* level or B level, respectively. There is strong trajectory to make significant improvement on this, and a move towards 3* level or A level or above, respectively (level 2, according to the Norwegian journal ranking system). We have high trust in this assessment, based on the evidence that there is already a small amount of publication output at this level in the Centre.

The Centre has a strong **potential to be internationally recognized** with higher quality research output and its impact. There is a strong trajectory for higher international standing, particularly in the largest Research Groups 3 and 2. Research Group 2 has already had publications in level 2 journals as well as a new major project with external funding. Research Group 3 is the most collegiate and inclusive, and has 7 collaborative projects. Research Group

2 has a clear plan for the next steps to be taken to become internationally recognized while Research Group 3 is experimenting with many options due to its size and large project portfolio.

Both Research Groups 2 and 3 have strong national standing. In Research Group 1, they have detected very relevant phenomena for study, they are nationally linked very well and there is great potential. Research Group 1 is now very small and new recruitments are needed if the Centre thinks that Internationalization Processes is one of the focus areas in the future. The quality of research output is the highest for Research Groups 2, 3 and then 1.

The Research Groups are founded to a large extent on **sub-disciplinary cohesiveness** of the publishing researchers. The Self-Evaluation Report and presentations from the Research Groups and the Centre provide good confidence in the ability of the Centre to achieve and present clear scientific analyses and new results. The members have **good theoretical underpinning** in their thinking and eager to establish their positions in the relevant scientific communities (especially in Research Groups 2 and 3). However, the current position of the Centre in relation to the frontier of research internationally can be further developed, e.g. more robust understanding of more various methodological endeavors and a more advanced understanding of cross-disciplinary boundaries and multi-level issues in management research.

The impact of the Centre's research to the scientific community, as measured by citation, is relatively low. However, this is a young Centre (2 years from its initial conception) and developmental time is required to fully establish the Centre.

As to the grading, we opt on this score to the grade between *very good* and *good*.

3. Productivity

There are **40 members** in the Centre, and **only 2.7 FTE research capacity**. This figure may demonstrate the high pressures for the individual members in the Centre to produce research output and to be research active, whilst at the same time servicing the huge high-quality teaching requirements. Despite this limited research capacity per person, the Centre has shown a strong 'buy in' from most of their members and a high willingness to excel in both the quality and quantity of their research output. The research-active members have spent an enormous amount of their free time to acquire **many grants**, from a great variety of (mostly Swedish) sources. Their past track record shows a great eagerness to go out of their way (in their free time) to produce a high number of scientific 'products' (scientific and related, applied publications; but also scientific research grants; conference visitations; workshops with collaborators in business; and other 'shows' of productive scholarship), per person, per FTE and per unit of this center. We think, therefore, that it is highly appropriate for the University to reward these people in the Centre, in a way, for their tremendous past productivity/efforts and outcomes, by offering them chances to boost their already high research productivity.

Given the high teaching load per Business Administration Faculty member, **the productivity of the Centre is very high** and it seems to excel vis-à-vis the other centres

of this University. This is justified by the very limited amount of full time equivalent (FTE) staff available for research. In addition, the processes for getting access to data typical in business and management studies, collecting it from the field, by also doing interventions/feedback workshops, is relatively time-consuming for the scholars, also because not many organizations/enterprises are always eager to spend their time working together with researchers from a university, despite its applied image. In many research projects which are based on qualitative data and strong involvement of the researcher in the field, the first scientific output of the research project is often a monograph, published in the series of the university. Thus it takes often many years before the articles that can be squeezed out from the monograph and contributions find their outlets in international journals. Moreover, the 'lingua franca' of the field of Business Administration is English. Given the fact that field research is mostly done in the national context and major revelations from the field are first formulated in the native language it is a handicap to publish in English if the research is based on qualitative methodology. This handicap is aggravated when the researchers do not teach in English. However, the leading scholars in the groups have surpassed these thresholds very well, even though it is relatively hard to publish in English, given the very-high writing standards that are present in the peer-reviewed journals within our field.

As to the grading, we give the grade *very good* (and we are not considering the number of PhDs completed, because the Centre does not have the mandate for such education).

4. Research environment and infrastructure

The formation of a **collective research environment** at the Research Centre level seems to be at an early stage. The formation of three Research Groups is a good start. At the group level, several joint research projects are under way. Research Groups 2 and 3 have acquired external funding for their research projects which will increase their productivity in the near future. Group 3 consists of 20 researchers, five of which are either full or associate professors. This gives to the group an opportunity to form some subgroups and specialize further at certain disciplinary areas, like in logistics. Group 1 has had a solid publication output even though the number of senior scholars is relatively small. The group has been able to counteract the lack of critical mass by collaborating in joint research and writing with scholars in other Swedish universities, due to linkages created during the PhD-studies in Uppsala University.

When considering the activities to form common Research Centre and Group level identities, it is important to pay attention to the fact that there are research areas and disciplinary commitments linked to individual researchers only. They obviously have looser relations to the core of the Research Groups. Some individual researchers may benefit from close collaboration with researchers in other departments/centres of the university. Such **cross-disciplinary linkages** may also help to create critical mass in new areas of research.

Because this Research Centre consists of Research Groups that cover a wide scope of disciplines within Business Studies/Administration it is natural that the scope of methodologies used is also wide. In some projects this is clearly a strength that has been taken into account. Research seminars and meetings are taking place with regular templates

which is a good practice. This demonstrates that members within each Research Group are actively engaged in research activities. The **joint-researcher seminar** that has been introduced in the Centre will help to create synergies across the Research Groups.

The **age profile** of the scholars involved with the Centre provides a good basis for the competence formation in the Research Groups. Many of the Associate Professors are **quite young** but have despite that shown **productivity** which is **remarkable even in international comparison**. On the other hand, the **gender profile** at the professor level is dominated by **males**.

Fairness in how this University deals with **promotions** of docents and professors is important, e.g. rewarding '**highly productive stars**'. The University does provide **matching funds** in rewarding faculty who have successfully captured external research funding, and this is highly commending.

The number of **PhD students** employed in or in linkage with the projects of the Centre is still very low. Presently, this is due to the sector wide constraint, i.e., the University of Skövde does not have a PhD degree granting right for this field. For this reason PhD students are enrolled in other universities, for instance in University of Jönköping, even though the main supervisor is working within the Centre. Even though the number of PhD students is low, there is strong evidence that the PhD students are pleased to be employed in the projects and are well integrated to the Research Groups.

As to international visiting scholars, there was not much evidence that longer term visits at the campus were occurring in the context of the Centre and that the visiting scholars would have taken teaching responsibilities, given research paper presentations in the seminars or participated in jointly organized workshops. There seems to be no infrastructure or resources are available at this stage to facilitate these kinds of processes. However, such practices would be crucial to facilitate the acceleration of the research environment in the Centre. It could lead to the professional development of the faculty, increase output with joint research and writing, be glued to new funding applications and further steps in international collaborations. The research environment and infrastructure can be enhanced with appropriate investment and resources from the University.

Dialogue with members of the Centre seems to suggest there is no Research Office/administrative support for grant application, costing etc. This is important to help reduce the time pressure of academics when applying for grants by focusing their effort on the content development of the bid, whilst consulting to meet the demands of the application template and the preparations of the budget are taken care by the administrator. This could be useful if the Centre has the ambition to attract EU grants (e.g. Horizon 2020).

As to the grading of this category we choose the grade *good* (even though there are some concerns that the amount of senior scholars is not large enough to cope with all the supervisory, mentoring, administrative and outreach duties that fall upon them, because so much still has to be done for reaching international excellence).

5. Networks and collaborations

The Centre's **national network and collaboration** seem to be established at the individual level and there are many long lasting and good relationships. Researchers participate actively in international conferences and make visits to universities all over the world. Members of the Research Groups 2 and 3 act as reviewers for international journals which is an important service to the academic community and a learning opportunity with which the group is likely to step up both the quality and quantity of their own research efforts. In addition, members of the Centre produce joint authored papers with academic research 'partners'.

Research Groups in the Centre have clearly strong external academic connections especially to the University of Gothenburg, Jönköping University and Örebro University but also to some other Swedish universities. This can be seen in the projects where senior scholars from other near-by universities are active partners. This has also facilitated the inclusion of doctoral students to the projects led by senior scholars of the Research Groups.

As to the **international connections**, there is evidence of joint research projects and joint writing of articles with carefully selected scholars in other countries: from which scholars will learn. In the Logistics subgroup, for example, linkages to academics in Finland are also well established. One Associate Professor in the Research Group 2 visits twice a year the University of Hong Kong and another one will be a visiting scholar at Charles Darwin University in Australia. Such visits help to create strong personal research links with relevant colleagues abroad. The degree of international interest (reach) is at its early stage. Although there are some individual links mentioned with Hong Kong, UK, Africa, Thailand and so on. It is not clear to what extent the research from this Centre has attracted international attention or international collaborative research, for example, joint research projects, joint publications, etc. The degree of national interest (reach) is more prominent with some **local universities with specific collaboration** such as PhD supervision arrangements and a 'shared appointment' of a faculty member.

For moving towards Research Centre level networking internationally it is a good start that within the Centre several interesting **cross-cutting research themes** have emerged between the Research Groups, e.g. resource based view, leadership theory, network theory, evolutionary theory, and change processes. When the actual benchmarking of relevant centre level candidates in the international context is done it is important to define the intellectual space of the Centre based on 'unique selling points' which are not too generic but take also into account the availability of data, access to companies and organizations, and potentially also the epistemic stances of the Research Groups.

As to grading this category we choose the grade *good*.

6. Coproduction and external cooperation

The **University has some strong engagements with the non-academic community**, such as the health care (hospital) sector, retail industry, IT industry, automotive industry and construction industry. There seems to be several joint projects and co-production activities with the Engineering and IT Centres (including one that involves this Centre focusing on healthcare/IT), and some are facilitated via the Gothia Science Park. However, the Centre has not demonstrated strong industry links or external cooperation being coordinated in a more systematic manner. The **cooperation** is done on a **project-by-project** basis, and an **individual-to-individual** basis (lacking a strategic-partnership approach which would otherwise boost productivity even further).

Coproduction of research and cooperation with external stakeholders are strategically important because it can **link basic research to the applied world**. It is also a medium to help enhance the opportunities to undertake **more high impact and relevant research** which are useful to the users and could make a difference to society. Given that the **mission of this University** is to **occupy their space more in the innovation sector**, coproduction mechanisms **could be made much more systematic or institutionalized** and the **Centre should exploit more of those mechanisms** (especially given that this Centre is –in its current name- itself about ‘Enterprising’.) However, it is recognized that not all researchers in the Centre favour coproduction, especially pure theorists; and that research results being undertaken with a more applied lens sometimes are difficult to be published in the higher ranking journals which is demanded from them at the same time.

The current predominant way of engaging with external ‘users’ in the research of the Centre seems to be ‘reactive’, and focuses more on data collection, e.g. surveying, even though co-designing of projects does occur: in which research is co-produced. The latter type of research is often more difficult to publish in high-level international journals (unless smart triangulation research design has taken place at earlier stages in the project which is highly commendable as a way forward).

As to the grading of this category, we choose the grade *good*.

7. Impact

In the spirit of the applied mission of this University, and given the limited amount of research time for each member of the Centre (due to their high teaching load), it cannot be expected yet that the Centre is scoring higher than ‘good’ on the current ‘grading scale.’ But the fact that with so limited resources the Centre has already met the level labeled as **‘national research of some significance to society’** is witness of its vibrancy and vitality.

Some of the collaborative research has been in the retail sector, in hospitals and the public sector at large. The textbook titled *Uppdrag butikchef*, for instance, has had an impact in the occupational development of the competences of retail personnel. Other research has had

impact on the national sports and the locally very important automotive, logistics and ICT sectors, but also the Swedish export industry is touched upon as well as the HRM sector.

In the SER report, there is one **impact case study** which is related to the **retail sector** research. This is a good example of how the research could make an impact to the industry. It will be useful to show some quantitative evidence of changes in the companies or sector as a result of this research in terms of its reach and significance. Because this is a new Centre, hosting relatively young research groupings with a very small total amount of FTEs, significant research impact is not envisaged. However, due to the nature of the research undertaken in this Centre, there are other research initiatives such as those in the healthcare and IT sectors which can be built up as significant future case studies. The potential to develop more high impact case studies should be considered. The Gothia Science Park linkage could play a role in this journey.

Measuring **reach and significance** of research requires evidential support, i.e., corroboration. Significance for instance should demonstrate how the research has made a difference to the industry or society. For example, a new business system/process created, % of cost reduction, etc. Reach for instance should demonstrate the scope of the impact, whether the changes have benefited (inter-)national users, other sectors etc. Impact of research measured by significance and reach has also been used in the Research Excellence Framework (REF) in the UK. REF not only measures quality of research output (publication), but also research environment and impact. Similar kind of measures could be considered here. The quality of impact case study can also be measured, using similar metrics to those of journal ranking/quality.

As to the grading of this category, we choose the grade *good*.

8. Strategies and plans for development of the UoA

The Centre's current **mission** is well aligned with the University's mission. An even more specifically formulated Centre **vision and set of associated strategic objectives and needs** (from the University and other stakeholders) may be helpful for all the parties involved. In such a short, concise document, the administrative relations, mandates and duties of the Centre and the Department have to be defined. How the Centre will work in the **governance structure** and what kinds of reporting lines are specified with respect to research and teaching duties which are distributed between the Centre and the Department. If the goal is to position the Centre to be a cost centre (i.e., like a department with administrative staff), then **full line management responsibility and budgetary control should be assigned and delegated to the Centre's Director**. As the focus of this Centre is research, hence **all businesses related to research in this disciplinary area should be the full responsibility of this Centre**, whilst teaching should be led by the Department. However, it is not easy to take into account the conflicting commitments of individuals who divide their work between research and teaching and often have unexpected deadlines for deliverables.

To establish a strong Centre requires strong and distributed **leadership**. Significant amount of effort and distributed leadership have been demonstrated so far in the journey from 2011

to 2013 in the development of this new Centre. The **strategic support from the University** is important and will be required to sustain the full development of this Centre. In the short term, it will be really useful, given the shortages of resources and high workload of members in this Centre, to be given some **strategic investment fund** to appoint additional high performing / research active faculty and some administrative staff in order to establish the Centre. Naturally, for longer term sustainability of the Centre, it is expected that the members of the Centre should also engage in thinking about their research line's **financial sustainability**.

The current leaders of the Centre do have a **good view on what are the next steps in developing a joint identity for the Centre**. Because the Centre is still at a formative phase of development it is understandable that an emphasis is needed on its internal development, especially at the level of the Research Groups and large profiling projects. A suggestion in this context is to carry out a so called benchmarking exercise, related to relevant international research groups with which contacts could be initiated in order to get a better touch of frontline research in the selected focus areas of the Centre. Such connections could be harnessed by organizing joint workshops, taking initiatives for editing books and special issues for journals and moving towards international projects for which funding from both national and international sources could be gained.

Particularly, given the limited financial research resources, the Centre and its members are advised to think through the best and most unique research profile with which they want to approach their 'markets/stakeholders'. The more narrow the **research scope**, the better for the research output (both quality & quantity), but then BSc Business Administration teaching cannot become too narrow. Hence we think that the profiling of the Research Centre might be best done in conjunction with thinking about a specific offer for one unique and attractive **research-led Master's Programme** which will secure both the reasonable amount of Business Administration students and step up the quality of the theses work. A Master's Programme topic like *Change Management*, for example, would cut across the three units of the Centre, and offer all current members of the Centre a chance to work with Master's students which will spiral their research output.

At the same time, it would be a chance to better promote the unique research profile of the current Centre without jeopardizing or negating all the energies of those who helped to build the Centre. (In the Netherlands, for instance, we know that this topic of Change Management is very attractive to both prospective MSc students and the labour market, particularly if the current research would be put to good use and slightly extended as well (into Change Management), perhaps at the cost of certain other topics that are already well-covered by other universities in this region (ideally, setting up a Masters should come along with seed research money: from the University).

Further development of such an integrative MSc Programme, alongside the research-profile evolvment, is a serious strategic aim that will bring more resources and growth/maturity to the Centre. In it, the unique profile of this group of researchers must be reflected so that it is hard to copy by competitors on the educational MSc-market in Sweden (and this profile would need to be reflected by an internationally appealing acronym: as its flagship (combined teaching and research) programme).

We note that the key elements for a **successful developmental path among the core actors** in the Centre are well-understood, like getting longer term external funding, strengthening collaborative relations with relevant foreign scholars, targeting high-rated international journals and forming longer term relations with external stakeholders to increase access to data needed in business and management studies, like being engaged in field experiments and action research to facilitate coproduction. By creating a stronger research environment, together with international colleagues, it will help to boost scholars' careers. Such outcomes are good for the University and its immediate stakeholders like the local community and the students concerned.

As to the grading of this category we choose the grade good.

9. Experts views on potential and recommendations for development

9.1. Recommendations to the University

1. The plan to **formalize the status** of the Research Centre (now still) called "Enterprises for the Future" should be done immediately. The research output meets in general high international standards. For this reason it would be important that **strategic funds** are allocated to the Centre from the University level at least during the formative stage until the financial sustainability is secured by long term external funding.
2. There are many opportunities to set up **multidisciplinary research projects**, across the current Research Centres of the University. The largest research group in the Enterprises for the Future Centre (Group 3) is ready for that now. On a longer term, unique niches in multidisciplinary research could be found when all the complementarities in basic research are taken into account and also the established stakeholders are involved in the specification of relevant research programmes. To explore such opportunities the University could allocate **annual funding for competitive bidding** as an incentive to Research Centres to set up multidisciplinary and inter-disciplinary projects across different Centres within the University. Such programmes and bidding processes would be good to be coordinated with key external stakeholders who become strategic partners to the programmes and provide also funding for the projects.
3. To increase the capabilities for research in the Centre, the opportunity to invite **Visiting Professors** to the Centre for specified periods of time would facilitate **jointly written articles and on joint research projects** with other centres in international universities. Visiting Professor and Distinguished Visiting Professor assignments will strengthen the self-confidence and competence of the research groups in the Centre and thus pave the way to **international cooperation with leading research centres in the world**.

4. In order to help scholars to make breakthroughs for their articles in high-ranking journals support for writing should also be arranged in the form of regular courses such as journal writing training. This will help **strengthening the critical mass of publication in high quality journals**.
5. Support for making applications to research funders from the content and budgeting points of view, especially if applications are sent to EU framework programs should be arranged by the University. **Setting up a Research Office** to coordinate all grants application procedures; well linked to funding bodies; release and announce calls internally; and identify cross cutting research funding opportunities will be very useful to all Research Centres.
6. To consider when **reviewing new recruits to** the University: to bring in staff with working life experience to enhance coproduction and research impact opportunities. This can be achieved via assigning a specific role for promoting knowledge exchange, including the responsibility for interconnecting and promoting basic research results to users.
7. The University has already provided strong strategic support to the establishment of this new Centre. Given that the mission of this University is more applied, there is a need to **improve the innovation chain to link the basic research to the applied world**. With the important **asset** of the **Gothia Science Park** at the door step of the University and given that there are already existing relationship with the Park, we recommend that this is an excellent opportunity for this Centre to play a role, particularly in the **business and management domain: co-production** to link many of the excellent research in informatics, virtual systems, systems biology and health and wellbeing, higher up in the innovation chain (i.e. adopted and used by industry, patent, new companies, etc). This will leverage the research strengths and complementary research objectives amongst all Centres, and will also deliver the mission of the University working with the Science Park, industry and the local and wider community.
8. To strengthen and diversify funding streams for research from the KK Foundation, EU and other external sources (e.g. alumni and corporate). This will require activating alumni networks, strengthening corporate engagement and being more actively involved in EU frameworks.
9. To enhance **promotion and incentives schemes to reward ‘research stars’** between the University, Department and Research Centre. This will help retention and attraction of high quality faculty and members of research groups.

9.2. Recommendations to the UoA

Department level

1. Initiative should be taken for applying for the mandate to **launch a research led Master's programme** that is aligned with the unique thematic competence of the Research Centre. Launching of such a programme would require more professor level faculty. In addition, the number of intake at the Bachelor's programme in Business Administration might need to be serviced by additional staff.
2. When the Enterprises for the Future Research Centre is established procedures for negotiating the teaching duties in the programmes of the faculty and commitments for research projects should be set up in order to avoid conflicting pressures for the use of working time and gaps in the capacity on either side. Such administrative procedures should be based on transparent rules which would lead into a sustainable, trustful and supportive working culture. A **clear workload model** is recommended.
3. Start considering what would be the right timing to apply the mandate for a **PhD programme** within the thematic competence areas of the Research Centre.

Research Centre level

1. To develop a **clear vision and business plan** in conjunction with the department and other research centres of the University what could be within the University's **unique niche (or niches)** where the existing **complementary competences in basic research** could be turned into **multidisciplinary research programmes** with **external stakeholders** who on their part are interested to provide **funding** for the projects in which **coproduction** is done and **international** researchers linked to the centres provide additional attractions to all the parties to be involved.
2. Set up **national and international mentoring** relationships for helping scholars to publish in good quality journals and become active in launching projects with international scholars with leading edge competences.
3. To enhance external stakeholders relations and integrate coproduction and impact framework into the research themes, we recommend that the Centre to **work in partnership with other Research Centres internally and externally** (including international), **activate alumni networks, and link with Gothia Science Park** and companies to demonstrate complementary across different disciplines and themes to link basic research to the applied world. This will involve acting as partner in joint funding proposals, help accelerating the profile of the Centre, increasing visibility and involving in high profile collaboration internationally.

Research Group level

1. Even though the Research Groups have been successful in finding relevant identities for themselves they are always in the process of transition due to short term employment relations in projects, due to promotions and new recruitments. Thus as a result of the **on-going strategic recruiting processes** for getting new faculty and due to potential promotions, there might be a need to provide **space for regrouping in and between the current research groups** as well as in connection with the groups in other Centres.
2. The members of the research groups should play a more active role as **impact makers** and working in **long-term collaboration with their various stakeholders**.

9.3. Recommendations to the Swedish government

1. To **value regional and small University's contribution to the education sector and local economy** in Sweden. The University is a key economic power in the local community and amongst the biggest employers locally. The existence of such a University is crucial for the local economy, community and people's growth. To provide **mandate and funding** to regional and small University to deliver and grow the local economy and community, working in partnership with the local authorities and industry.
2. To **review and consider 'reform' of the degree awarding structure and language used** in the education sector in Sweden. **More autonomy** is required for the regional and small University to award the PhD degree. This is essential to grow and develop **niche research capabilities** nationally. **English** to be used as the common language in higher education will help internationalise and open up the excellent **talent pool** in Sweden internally, and also attract international talent externally.
3. To review and support **regulation for more autonomy** to regional and small Universities: to offer and **deliver education and research nationally and internationally**. Due to heightened competition within the education sector, this flexibility will enable internationalisation of education and development of specialised/niche research which is good for the (knowledge) economy at large.
4. To support a University with strong applied research which is linked to strong basic research. This will help accelerating the innovation chain nationally and internationally.



UNIVERSITY
OF SKÖVDE

Assessment report

Health and Well-being: Individual and Society

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1. General assessment of the UoA

In our view, this Unit has demonstrable strengths and substantial weaknesses. Their strengths lie in the areas of Midwifery, Nursing (including RSPH) and Ageing research. In these areas their publication output is high.

The overall weakness is in the focus, organization and structure of the Unit. This Unit very much needs a fundamental reorganization so that the researchers can build on their strengths. Another weakness is the lack of resources for research and networking, mainly financial support and the insufficient number of senior researchers.

We would like to commend the faculty and staff for their dedication and commitment to the development of this Unit.

2. Quality of research

Overall, we assess the quality of research of this Unit at present is approaching Good. We stress that, given the size of the Unit and, more importantly, the restrictions that individual researchers face on their available time and resourcing, that their research constitutes a good achievement.

There are also specific trends that are encouraging: there has been, in particular, a trend upwards in the number of publications in high-impact international journals which should be applauded. We note that in some research areas, in particular ageing and child-bearing, the quality of the research reaches the standard of Very Good. The publications in the social resource theory – although as we shall suggest below may not be clearly linked to the core strengths of this Unit – are clearly of high quality.

Much of the research output of this Unit appears in journals that are scientifically respected, if somewhat highly focused or specialised. Other areas of research do not appear to us to be nearly as advanced, or relevant to the Unit's core strengths. Nonetheless, the upward trend in peer-reviewed publication is impressive, once again, especially in light of the small size of the Unit and the obstacles individual researchers are required to overcome.

3. Productivity

Overall, the output of the Unit is Very Good, in light of their work conditions, including time restrictions and other limits on the available resources for research. We notice in particular a remarkable increase in the number of articles in international, peer-reviewed articles in the past 7 years. We believe that there is sufficient evidence to be optimistic about on-going productivity amongst these researchers, given their past performance, and clear devotion to their research areas.

The group felt that, despite the extensive bibliometric data with which we were provided – with multiple tables collecting information about very specific aspects and dimensions of research output – it remains difficult for us to assess these data to reach clear conclusions. It is possible, and this is the value of the information provided, to identify trends. But we thought that without a means for comparing the outcome of this Unit with similarly-situated

units – or even to compare this Unit with the productivity levels of other Units of Assessment – that the information was not as useful as it could have been. It should also be said that some information was somewhat opaque for us: e.g. we were unclear what the figures in the bottom two rows of Table 2.2.3 meant, or what information they are intended to convey.

It was brought to our attention that the University of Skövde is the most productive university in Sweden when output is measured against funding – or in other words Skövde appears to be a highly cost-effective research producer. Moreover, we were informed that, within the University, that the number of citations in 2012 in the Health and Well-Being Unit was the highest among all of the Units, and that this fact was due almost entirely to publications in the health area. Reliance on the Norwegian Score (about which we were skeptical for other reasons) apparently hides these facts and therefore may not be an accurate representation of productivity in this Unit.

4. Research environment and infrastructure

The physical environment

We were very impressed by the physical research environment here at Skövde. The training facilities, laboratories and equipment all seemed to be of a very high standard. The offices and meeting rooms are exceptionally good, certainly compared with other research settings of which we are aware.

The Research Organizational Model

For reasons that we will more fully explain below, the organization model for this Unit (as depicted, for example, on page 6 of the Self-assessment) is inadequate, confused, and misrepresents the actual situation that exists amongst these researchers. The model, we believe, is in fact counterproductive since it steers researchers in misleading directions. We got the distinct sense that researchers, especially those outside of what we take to be the core strength areas of the Unit, were forced to manipulate their own research interests – some of which are well established – in order to accommodate the demands of the model and fit under the rubric of ‘health and well-being’. This, we believe, can get in the way of the pursuit of fruitful lines of research the germs of which are already implicit in on-going research. In addition, the model should more adequately reflect the competencies and potential collaborative synergies that already exist or are latent amongst the researchers in the Unit.

Among other things, there is no rationale provided for the putative ‘columns’ in the organization model of Unit, and they identifying names -- WellCam, LearnWell, etc – are idiosyncratic and would not be recognisable to an external researcher seeking collaboration, or a potential Phd student looking for like-minded researchers. There is no rationale given for the addition of the SocInc and it appears to have been added to accommodate ‘left-overs’ that, because of the enormous umbrella of ‘well-being’, needed to be fitted in.

The research staff

We were impressed in many of our face-to-face encounters with energy and devotion to individual interests and projects expressed by the researchers. Others were less enthusiastic, and we very much got the impression that they were somewhat resistant to the perceived need to alter their own research interests to fit with those anticipated by the Unit’s organizational model.

What was clear to us was that the researchers of the Unit very much need a coherent research programme that integrates their diverse interests. We understand that this may mean that some of their interests may have to be given up, or that they may need to develop new interests or new perspectives on their own interests. We believe, as we recommend below, that the much-needed coherence requires strengthened personnel at the senior level to provide leadership and direction.

The University research infrastructure

We note that there does not appear to be any University-level group or individual that can support Unit researchers in the essential task of making applications for funding at the national and European Union levels. Indeed, we were given no information about the presence of any research-orientated infrastructure available, something without which it is

extremely difficult to establish an international presence and to be successful in applying for funding from important sources such as the European Commission, Nordic foundations and other transnational and international funders.

Other research environment issues

There is a remarkable lack of gender balance in the Unit that may be representative of this area of professional and academic focus, but may affect the research perspective and the potential for its social impact, and should be factored into further development plans. At present there is homogeneity of professional and academic background and the Unit could profit from a greater professional and academic diversity, especially in light of the intrinsically interdisciplinary approach that is, correctly we believe, adapted in the Unit. Consideration might be given to experts in demography, sociology, anthropology, epidemiology, and methodology and statistics, as examples.

5. Networks and collaborations

On the evidence presented we found that there is a very limited degree of national and international networking in this Unit, and what there is, is weakly based on co-supervision (Table B1.3.2). Nor did we see any clear evidence of strategic planning to develop effective academic partnerships in the future. We were informed that there was a concern that some researchers were continuing to work with their PhD supervisors at other universities and that this was drawing them away from Unit research. We do not share this concern, as long as these – and other – academic contacts are fostered and built on for further networking. We were encouraged by the information in Table B1. 4.1, that suggests a high level of participation in the academic community, since this can be built on for networking purposes.

We see few indications that Unit researchers have tried to identify academic partners, or more importantly to orient their research so as to align themselves with existing international research communities and organizations, such as those centered on health promotion and caring professions. This would help to generate the necessary networks for collaborative research. We note that one of the primary obstacles to a flourishing research agenda that small universities face, in our own experience, is that of isolation: there is an absolute need to reach out to link up with established allied research nationally and internationally to benefit both from the infusion of new and current ideas, and to enhance the impact and relevance of the research carried out at Skövde.

We are pleased to see that the Unit researchers have established good connections with regional and local health settings, and feel that these can be built on and enhanced in the future. We felt that there was limited contact and visibility in the public sphere given that there was little information concerning outreach present in the documentation.

6. Coproduction and external cooperation

We notice that the Unit researchers have been successful in integrating regionally and have established collaborations with the Skaraborg Hospital, some local municipalities and a private company in the region. Although we appreciate that access to patients for research is essential, we notice that there is limited contribution and cooperation provided by these

collaborative partners. Other than the recently-created strategic group associated with the two health boards, we could find no evidence of on-going collaborations that are currently in force. We were informed of some national and international collaborative endeavors. We think that it would be very important to develop these. Finally, we were given no information on coproduction.

7. Impact

Several of the researchers in the Unit have done research that has had some impact on clinical practice in specific health settings, although it is hard to find clear evidence of the nature or extent of this impact. The impact described in the self-assessment report focuses on professional support and clinical practice, as described in the two impact cases. Recognizing that it is an on-going challenge amongst researchers in the health area, broadly construed, to identify, let alone, measure the impact of their research, we suggest that these researchers should be focusing on the impact of their research on service users' experience of these interventions in the various settings.

8. Strategies and plans for development of the UoA

There is a noticeable lack of provision for strategic or developmental planning in the Unit. This is unfortunate since this Unit very clearly needs to find a way to organize themselves so that it builds on their strengths and develop strategies and collaborations that are meaningful and organic, rather than administratively imposed, top-down. This is reflected in their statement of primary mission and goals, which is unfocused and amorphous, and based on factual claims that are somewhat dubious. This Unit, we believe, simply lacks a clear idea of what it is about, which makes it extremely difficult to envision, not to say make strategic plans for, its future. A strategic exercise to lay the foundations for this Unit is essential.

Such a strategic exercise would investigate the actual state of affairs, regionally and nationally, with respect to emerging problems, such as the growing health inequalities among immigrants and other marginalized groups, and the increase in incidence of dementia. This exercise would, *inter alia*, clarify the constituencies the researchers wish their research to serve - such as women during pregnancy and childbirth, people with chronic pain, the elderly who wish to remain in their homes. Then they could marshal their research strengths to identify research questions and pertinent research collaborators outside of their professional and academic domains. Finally, the strategic exercise would clarify the added-value of their existence as a research Unit – what precisely makes them a coherent unit, what are their strengths, how these can be developed and enhanced in their future research, and what directions they wish to pursue, as a coherent research group.

9. Experts views on potential and recommendations for development

9.1. Recommendations to the UoA

We believe that the structure and rationale of this Unit need to be re-envisioned. This is an exercise best left to the researchers themselves, perhaps in an organized and facilitated strategic exercise. The viability and sustainability of a research Unit, or Centre, ultimately depends on the investment which the individual researchers are committed to making to the Unit, and this presupposes a coherence of message and clarity of aim that is simply lacking in the current organizational model. There are several specific recommendations that we make below, to the Unit and to the University, but at the outset we wish to offer our recommendation with respect to what we believe are the most appropriate rationale and focuses of this Unit. We offer these remarks as suggestions.

Revisioning the Unit

It is our view that the organizational model as currently envisioned is inadequate. So too is the title of 'Health and Well-being'. Both terms are extremely broad and open-ended, the term 'Health' may have biomedical connotations that are not descriptive of the research focus in this Unit, and 'Well-being' is a highly contentious concept with vague boundaries. We strongly believe that the Unit needs to be grounded in its strengths and to build on those, before trying to identify potential collaborating partners.

In our view, the core areas of research strength in the existing Unit are: Midwifery (including RSPH), Nursing, and Ageing. The focus of separate research projects would standardly be labelled as Health Promotion and however inadequate that label may be, it is internationally recognised and accepted to denote a coherent research perspective and practice. In order to designate the unique approach that the Unit takes in its health promotion research, we proposed the word 'Caring'. Hence, just as a matter of labelling we would suggest the *Unit of Health Promotion and Caring* (HP&C).

We believe that these professional and academic areas have produced good, solid research at University of Skövde and that the future for these research areas is promising, especially Ageing. In light of the fact that nurse credentialing has returned to the curriculum, and perhaps the emergence of advanced nursing practice in Sweden, there is a bright future for health promotion and caring research that, among other things, serves the interests of professional education. For example, nurse and midwifery education can greatly profit from research in assessment and quality outcomes. The current research on ageing, although in early stages in Skövde, could easily be enhanced through collaborations with other Swedish research centres, such as the one in Universities of Jönköping and Borås, to produce very promising results.

We find it important to develop a coherent research group by identifying and concentrating on what researchers are good at. At Skövde, we believe that this means building on research areas of midwifery, nursing (including RSPH) and ageing through an investment of resources and energies in these areas. Furthermore, we recommend seeking more joint projects with clinicians in order to expand the potential for research and disseminating findings, which would increase its impact.

We strongly believe that there is no value in forcing a research agenda – especially one so vague as ‘well-being’ – on the current collaborators, in particular Social Psychology, Education, and Public Health. Their research is valuable in the context of their disciplines, but is not directly aligned with the research of these three core groups, and forcing them to be artificially aligned, we sense, has not been a welcomed development.

Collaborations with these and other groups across the University are obviously potentially of high significance; but these collaborations should be allowed to develop organically, after the three core groups have found their own coherent ‘story’, their understanding of what they do, what makes it important and interesting, who their constituencies are, and what the added value of their ‘approach’ is.

Enhancing strengths

It is very important that Unit researchers maintain and strengthen their focus on ‘applied’ health promotion and caring research, and to further secure linkages, not only with other academics, but with regional organizations that can profit from collaboration, and from whom the Unit researchers can profit as well. Closely working with regional groups can be the source of ideas about research needs relevant to this environment, in terms of which applied research can be developed.

We also think that it is important for the Unit to maintain and enhance its commitment to interdisciplinary research and the use of multiple methodologies, both quantitative and qualitative. The research would benefit from a genuine ‘mixed methods’ approach in which several methods are used together in an integrated fashion. We notice that the Unit researchers have avoided the ‘illness-centred’ approach to health in favour of a more salutogenic or health promotion approach and we encourage the researchers to use this as part of the ‘story’ they wish to tell.

Developing projects

We also believe that the researchers should be allowed to pursue their research interests within the framework of the agreed upon coherent and truly unified conception of their research. We would only caution them in two regards: a small research group needs to be aware that they cannot immediately compete head-to-head with a larger, and well-funded, group. For example, we are aware that there is a substantial complementary and alternative medicine group in KI that is well-funded and engaged in on-going research in this area. Other than cultivating collaborative partnerships with this group, it would not be advantageous to continue to research this area in isolation. Secondly, if in the research question one wishes to investigate what might loosely be called ‘non-standard’ therapeutic interventions such as sterile water injection, mindfulness, acupuncture, yoga therapy and so on, given the general scepticism about these interventions, it is essential that the highest level of methodological rigour be used in the research to gain academic credibility.

Visibility

It is important to emphasise that the future of the research done in this Unit depends on international visibility. Efforts should be made to attend and participate in international conferences, to network extensively among researchers working in similar areas and to develop robust and sustainable consortia of complementary researchers across Europe who can then bring together their combined expertise and apply for large, multi-centred, European grants. Directly serving the interests of the region is important, but the significance and sustainability of the research depends on international visibility and networking.

9.2. Recommendations to University of Skövde

We were told that one of the challenges that this Unit faces is attracting and keeping senior researchers. We believe that there are several reasons for this, many of which are not remediable by the University but involved wider socio-economic factors. But it should be said, that it will only be possible to attract senior individuals if there is a relaxation of the current practice of distributing time between education and research. It is difficult to imagine any research agenda being sustainable for long when as little as 20% of one's time can be devoted to research. A more flexible arrangement whereby highly productive or promising researchers can negotiate a higher proportion of time is recommended.

The University should also consider a more realistic and effective incentive structure that awards highly productive or especially promising researchers with the single resource that is most productive of research, namely time. In addition, as any successful applicant to a large European Commission or similar multi-centered grant will attest, it is impossible to be successful without support. This support in some universities is purely financial, with 'seed' money being allocated for research development. But especially for complex applications, it is essential for the researcher to have access to the specialised expertise of grant writing. Without this support, much time in grant preparation is wasted and the outcomes are disappointing.

As we listened to researchers in this Unit throughout the week we could not avoid sensing amongst some of them not only a low degree of identification, or even alienation, with the Unit to which they have been assigned. We believe that the 'top-down' approach to creating research units is not conducive to the full engagement of a researcher since the creation of artificial research associations may be resented. At the same time, we sense amongst some researchers a very strong identification, devotion, and engagement with their own research and they have developed constructive informal working relationships that the University would be well-advised to allow to flourish and to support.

9.3. Recommendations to the Swedish government

We suggest the University establishes a strategic link to one of the 10 senior universities to strengthen their research capability and capacity.

We urge the Swedish Government to review funding arrangements for the smaller universities to facilitate the above strategic links and assist the universities to invest in senior research staff so that they may strengthen research leadership.



Assessment report

The Informatics Research Centre

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1. General Assessment of the Unit of Assessment (UoA)

In 2013 we were invited to participate as experts in the assessment of research and collaboration as a whole in the Informatics Research Centre (IRC) at the University of Skövde (HiS) from a national and international perspective. A self-assessment report from the IRC was provided to us during the summer of 2013. The self-assessment report covered the period from 2007 to 2012, and included strategic information about the IRC, quantitative data describing the IRC, and two case descriptions describing research projects and their impact. From 8-13 September 2013 we convened as a panel in Skövde. During this week we learned more about the IRC through presentations and conversations with researchers and administrators at the IRC and university. At the end of the week we drafted our assessment report as requested. Feedback on that draft was provided to us by the IRC on 23 September. In response to that feedback, clarifications were made to the draft report. This document is our final report. As requested it first presents our general assessment, or overview, of UoA, i.e., the IRC. Subsequent sections discuss the following aspects of the IRC: quality of research, productivity, research environment and infrastructure, networks and collaborations, coproduction and external cooperation, impact, strategies and plans for development, and recommendations for development.

In the review period (2007-2012) the Informatics Research Centre (IRC) has published more than 400 peer reviewed papers addressing topics of high relevance to science and to society. It has attracted funding from local, national, and international agencies and business partners. Researchers at the IRC collaborate with research partners globally and locally, and participate in forums to set national and international policies. Since 2007, 30 doctoral degrees have been awarded to IRC students.

Located adjacent to the Gothia Science Park, the IRC's facility provides a variety of spaces for research and meetings. Whereas the physical facilities are excellent, there is a need for more resource support for technology infrastructure.

The researchers associated with the IRC are divided into five research groups, with one additional group recently added. The size of these groups in the IRC varies over time, and group size ranged from 6 to 22 members in September 2013. Per December 2012 and September 2013 staffing levels, the number of professors is low for this number of groups. A higher level of staffing, including a larger number of professors, would be expected.

We see significant impact of the IRC's research on society, through fundamental and applied research, although there could be improved reporting of these impacts.

The panel takes the view that one of the strategic goals of the IRC strategy should be a suitable balance between achieving societal impact through scientific output on the one hand, and educational programmes on the other hand.

The panel arrived at the scores below by positioning the performance of the IRC from a national and international perspective, while also taking into account the resources that were at the disposal of the IRC during the evaluation period (2007-2012):

Quality of Research:	Excellent
Productivity:	Very Good
Research Environment & Infrastructure:	Very Good
Networks and Collaboration:	Excellent
Co-production and External Cooperation:	Excellent
Impact:	Very Good
Strategies and Plan for Development:	Good

2. Quality of research

During the review period the IRC has been engaged in a number of innovative research projects that have resulted in several contributions to high-level journals (e.g., Artificial Intelligence, IEEE Transactions on Software Engineering, Information Systems Journal, and Journal of Medical Internet Research, ACM Transactions on Software Engineering and Methodology, Information Fusion, and IEEE Software) and conferences (including prestigious IEEE events) and had an impact on companies and organisations outside of academia. There is, however, still room for improvement as far as targeting these and possibly other high-level publication channels (e.g., *MIS Quarterly*, *ACM Transactions on Computer-Human Interaction*, and *Journal of the American Medical Informatics Association*) is concerned. On the whole, the project publication portfolio is characterised by a good balance between basic, applicable and applied research.

Given the size of the University and the number of research staff, it is clear that the IRC can only cover a small part of the broad range of possible research topics. With this in mind it can be said that the areas and themes addressed by IRC researchers (e.g., Information Fusion, eHealth, human-machine interaction, open standards and open source software, serious computer games) are pertinent and in line with societal and industrial needs and demands. There may be additional opportunities for cross-fertilisation between the areas chosen (e.g., between Information Fusion and Robotics), as well as potential to increase effectiveness and impact. This could be achieved by further expanding and integrating research expertise that addresses more complex issues in society. Examples of such opportunities may exist in eHealth, Informed Decision Making, Research Data Archiving through Open Standards, Disaster Management, and eFarming. Opportunities like these could be identified collaboratively within the IRC.

In some areas, IRC research is at the leading edge, both nationally and internationally, and is recognised as such. This is proven by Google citation figures for individual researchers and IRC participation in international projects. ICEA, a large European funded project of the IP type (Integrated Project, FP6 programme) has been coordinated by members of the IRC. In addition, the IRC has been a partner in other, smaller European FP6-IST projects as well as in projects funded under the EUREKA scheme. The IRC continues to be successful at the EU level. A large FP7-ICT IP (in Cognitive Systems and Robotics, DREAMS) led by the IRC, and a competitive procurement project (on open source software and standards) with IRC participation, are currently being negotiated.

IRC researchers cooperate with their peers in academia, both nationally and internationally, as well as with partners in industry and public organisations. They are engaged in joint actions (e.g., EUCOG2 and EUCOG3, two EU funded networks of researchers in Cognitive Systems related areas) and contribute as members of editorial boards and programme committees.

The high standard of research in this IRC is also confirmed by the fact that it underpins the University's first and, so far only, approved PhD programme, and the IRC's participation in a multinational EU-supported doctoral training network (RobotDoc). Moreover, the IRC has been successful in attracting new faculty members with international standing.

3. Productivity

We recommend assessing productivity based on internationally accepted standards and measures. An example of such standards with some overlap with the IRC's disciplinary areas is the journal ranking created by the Association for Information Systems available at <http://ais.site-ym.com/?JournalRankings> and Thomson Reuters journal citation rankings. Another standard is the CPP/FCSm metric - the impact of a research unit's articles, compared to the world citation average in the subfields in which the research unit is active.

As far as productivity can be judged based on quantitative measures in terms of number of publications through various channels, the relevant figures provided in the IRC's self-assessment report indicate a very good level of output over the review period when taking into consideration the number of researchers and their time available for research in the IRC. While the overall level of productivity of the IRC as a whole is considered very good, productivity across the various research groups appears to vary. This means that there may be opportunities for publications that are not currently exploited. It is therefore suggested to involve more explicit planning earlier on in projects, of the types of publications targeted. Currently, it may happen that the demands of generating additional research proposals and establishing new research projects supersedes the effort of reporting scientific results from projects whose funding has ended.

The average number of PhDs and Licentiates awarded to IRC students per year is high. The IRC's own Informatics PhD program was approved in 2010 and has already resulted in two doctoral degrees. No figures were given for Master's theses although one may assume that Master's level training should also benefit from high-level research activities.

The IRC's performance in terms of acquisition of external funding (both national – e.g., from the Knowledge Foundation, and international – e.g., from the EU Commission), resulting in an impressive number of projects, is noteworthy and to be commended. Individual project funding ranges from (the equivalent of) several thousand to over 1.5 million Euro.

The number of publications in relation to total funding expended is among the highest within Sweden (#publ/MSEK). This demonstrates cost effectiveness, value for money and high return on research investment to society.

4. Research Environment and Infrastructure

The research facilities in the IRC are primarily located on the fourth and the fifth floor of the Portalen building on the campus. Additionally the group is sharing a demonstration space in the first floor together with another Research Centre. In the demonstration space, the IRC is hosting its Volvo car simulator infrastructure, which has been used as an experimental research platform for many research groups and projects for many years now. The research environment, including office equipment and layout, is modern and well-suited. The expert panel was impressed with the fact that the physical infrastructure is designed with visitors in mind as well. Furthermore, the co-location of the Gothia Science Park in the same building offers opportunities for networking and co-production. The facilities are easily accessed and offer an opportunity for hosting all kinds of events. The IRC also has a small “flat” furnished by IKEA in another building, which is mainly used for usability studies and student driven activities. The current physical environment available to the IRC is excellent. However informatics research often requires specialised IT-infrastructure outside the IT support generally provided to a university as a whole, and we encourage the University to work with the IRC as needed in this regard to facilitate their high quality research.

IRC research is organised in five research groups: the Distributed Real Time Systems research group, the Information Systems research group, the Interaction Lab, the Skövde Artificial Intelligence Lab and the Software Systems research group. Additionally, the IRC has decided to set up a new group in the area of Media, Technology and Culture. This group plans to start its research activities in 2013/2014. The size of the groups in the IRC varies over time, and group size ranged from 6 to 22 members in September 2013. Some groups (e.g., the new media group) have no full professors while others may have up to three (e.g., the Interaction Lab group). Having 2-3 full professors per group would bring additional energy, creativity and sustainability to groups. There is a concern as to whether the IRC's internal structure is flexible enough to encourage mobility, support and interaction between groups. For example, a new senior faculty member joining the IRC could be encouraged to initially interact and explore synergies and opportunities with all groups, before finding his or her place in one or two groups.

There are altogether 30 permanent (13.4 FTE) researchers of all levels in the IRC. Of these, 5 are full professors, and 3 are associate professors. In addition, the research groups have 18 temporary research assistants and other personnel (10.9 FTE) to support their work. At the assistant professor and lecturer levels there is a lack of gender balance. It appears that all staff are fully engaged and it can be challenging to quickly recruit the additional personnel needed to work on newly-funded projects.

The senior professors devote the majority of their time to research related activities. Of this time, a significant portion is spent on acquiring research project funding, which is common in most European universities. In the long run there is a potential concern as to whether the currently excellent quality of research can be sustained if writing grant applications reduces the time senior researchers are able to dedicate to actually doing research. Full professors, unlike more junior faculty, generally do not have (university-funded) time that is exclusively dedicated to doing research except when they first take up a position at the university. This can be problematic because it basically forces a full professor to competitively obtain money from funding agencies in order to engage in research activities.

The IRC's research is led by research group leaders. There exists a formally agreed structure in the IRC for research leadership, and the research groups today have a significant degree of autonomy to decide the direction of research, the publication venues, the funding targets, and the selection of collaboration partners as well as short/long term goals. At the project and group levels the work environment appears collegial and supportive. At centre level it appears that many responsibilities are shared or distributed, and thereby it is hard to pinpoint any single person responsible for specific tasks relevant to the centre as a whole. For example, the IRC's web site could be enhanced. Currently, each research group presents different types of information (which has an impact on how the unit becomes known internationally). Thus, the roles and responsibilities are not clear at the centre level while they are mostly clear at group and project levels.

The IRC receives some funding from the University to support on-going research activities. This distribution is not automatic but depends on the situation of each particular research group. Although it is unclear to the panel how distribution decisions are actually made, the process seems to fit well within the IRC's culture.

Funding agencies (e.g., Vinnova) are decreasing their support for doctoral student research, and the IRC has been increasingly hiring postdoctoral fellows instead. While this may be positive from the viewpoint of high quality research it can be counterproductive in the long term. Good PhD education requires the ability to work in demanding research projects. Research projects create unique and rich learning opportunities for junior researchers. Furthermore, the regional industry has expressed the need for PhD graduates to work in companies.

The research that takes place at the IRC needs publicity and visibility in order to have a greater impact on the region and beyond. Currently, it appears that research projects must generally create their own publicity. Press releases are sometimes authored with the help of individuals in other organizations. A university-level press strategy and dedicated press support is encouraged.

While there exists a personal level activity plan process, plans may not always identify measurable goals and there is no systematic follow-up procedure and accountability. Personal, group and centre-level plans are a way to communicate the centre's intentions at various levels; however it appears they do not have a significant role in the IRC's daily activities today.

5. Networks and collaborations

Individuals in the IRC have excellent connections to national and international academic networks. This is evidenced by: (a) the large number of successful EU and national project grants (10) awarded to members of the IRC yielding collaborations with over 50 institutions; (b) the high degree of participation in international conference program committees by IRC members (members participated in over 100 conference program committees during the review period); and (c) the number of invitations to review manuscripts for international journals (members reviewed over 100 manuscripts during the review period). Continuing to identify ways to leverage national and international networks and disseminate information

about the IRC's participation in networks will increase the visibility and impact of the unit's research.

Less evidence has been provided of participation in international scientific and professional networks at the *centre* level, e.g., organizational membership in scholarly societies. The panel sees such participation in international scientific and professional networks as an opportunity; it will most likely increase in importance if and when the new school is formed. Examples of networks the IRC and/or school might want to participate in include the iSchools (<http://ischools.org/>) organization, the Association for Information Systems (<http://ais.site-ym.com/>) and the Computing Research Association (<http://www.cra.org/>). Specific research groups might also more explicitly position memberships of e.g. IFIP working groups, and more research area specific networks. Membership in these types of organisations provide several advantages, including:

- supporting innovation, best practice as well as peer mentoring and problem-solving with respect to academic leadership at the centre/school level;
- highlighting the research conducted at the centre/school;
- helping to recruit well qualified PhD students and academic staff;
- unique learning opportunities for students and junior colleagues via participation in doctoral colloquium; early career mentoring; industry-sponsored competitions, prizes and awards; student exchanges within the discipline outside Europe, etc.

6. Coproduction and external cooperation

The IRC has excellent long-term and short-term collaborations with organizations outside academia. Successful collaborations exist with large (e.g., Ericsson/Saab) and small for-profit companies (e.g., Visuera Integration AB, ImCode Partner), government agencies, non-profit organisations, and industry associations (e.g., Open Source Sweden.) The case studies presented demonstrate effective and integrated research with external (non-academic) partners. Examples have been provided of several long-term relationships which provide evidence of the ability to not only establish these relationships but to maintain them over time. Further evidence of successful research collaborations with non-academic entities includes: external organisations such as municipality directors and professional unions contacting the unit for assistance; participation in international policy-making groups; and the number of PhD students financially supported by non-academic external partners. The latter may become increasingly important given the emerging trend of national funding agencies preferring postdoctoral fellows to work on projects, instead of doctoral students.

The IRC does an excellent job leveraging these collaborations to sustain and form new high quality research projects. A challenge for research organisations like the IRC is to include basic research activities in co-production projects. Additional resources, e.g., research time not allocated to specific projects that is used for reflection and writing, could be allocated on a trial basis to help address this challenge.

The IRC, and the HiS in general, should seek additional ways to leverage the IRC's collaborations with non-academic partners. For example, a combination of quantitative metrics, such as regional job creation and cost savings generated for partners, and qualitative

testimonies from partners, including video and text testimonies on the IRC website, social media sites and promotional literature, could help raise the profile of the IRC and assist in attracting additional resources. Administrative staff could be tasked with collecting and presenting such evidence.

7. Impact

The IRC has provided strong evidence of the impact its research has made on society. The centre uses different means to create this impact. For example:

- Research projects conducted by the IRC typically involve practitioners from different for-profit and not-for-profit organisations. This is supported (and further strengthened) by informal contacts with a number of practitioners interested in participating in research activities and/or using research results.
- Researchers working at the IRC have a broad network involving internationally and nationally recognized actors, and are also involved in a number of on-going collaborative initiatives that focus on research and practice.

This work had and continues to have, a clear regional impact, including knowledge transfer to companies, and the creation of new services/products - both helping to establish a sustainable innovation region.

Given that the mission of the HiS research centres ultimately focuses on research towards application, one expects a more explicit capitalisation and communication of the societal impact of research activities. Although there is ample evidence of societal impact and the drive to create impact has been internalized by the individual researchers, there appears to be room to further institutionalise and facilitate this at the centre, university and governmental levels. More specifically, the panel sees potential opportunities in terms of:

- More focused/structured communication to society regarding the mission/role of HiS and the impact achieved across the University. Improved HiS-wide support is considered desirable.
- More explicit quantification and communication of the impact on the local economy, of the IRC's and the University's activities on the local economy; this includes innovation, job creation, purchasing power (direct/indirect contribution to local spending power), and attraction of new firms. (This is also discussed in the section, Co-production and external cooperation.)
- More transparency (both internally and externally) with regard to the knowledge-chain, linking (use-inspired) basic research with applied research, in order to create additional impact in society.
- More activities supporting the knowledge-chain in terms of systematic creation of spinoffs and start-ups, commercialisation of research outputs, e.g., with the Gothia Science Park or incubator organisation.

8. Strategies and plans for development of the UoA

The panel sees the University's initiative to conduct the ARC2013 as a positive step towards the further development of the University and the IRC in particular. There is a positive drive among the members of the IRC to further develop/strengthen research in the centre and the University.

The panel takes the view that one of the strategic goals of the IRC strategy should be a suitable balance between achieving societal impact through scientific output on the one hand, and educational programmes on the other hand.

IRC researchers are dedicated to and passionate about their work. Individually the research groups have been successful in identifying and addressing socially and scientifically relevant issues. However, the panel did not get a sense that there currently exists a centre-wide shared identity, shared goals or sense of pride in contributing to the excellence of the IRC as a whole. As a result there may be missed opportunities to capitalize on synergies across groups within the IRC, including collaboratively identifying and addressing complex issues and challenges. The panel believes this is an important consideration in the development of research in the context of a new university. The specific challenges brought about by the funding constraints, the regional role of the University, and its relatively small size, make it desirable to have a clear research identity and synergy within and across centres. This is also important considering the junior faculty members who join the IRC now and in the future.

Overall, the IRC has great potential to expand its research and increase its impact. On-going, collaborative strategic planning is necessary for setting centre-wide goals, targets, plans and values and communicating them within the IRC and beyond. This will increase the visibility of the IRC's research activities and results. Research groups may also benefit from joint strategic planning as it removes duplicated efforts (in public relations as an example) and may allow new innovative ideas and collaboration opportunities to emerge more effectively and naturally.

9. Experts views on potential and recommendations for development

In the following, the panel offers recommendations for the development at three levels: 1) the UoA, 2) the University and 3) towards the Swedish government.

9.1. Recommendations for the UoA

Organisation

A collaborative, on-going and transparent approach is needed for strategic planning, vision articulation, regular review of mission, and value creation.

To assist the IRC in identifying the important strategic focus areas and opportunities for business innovation and societal impact, there should be an external Strategic Advisory Board that meets at least once a year. The recommendations listed here could be regarded as initial recommendations of such a board.

There is a need for a more explicit and integrated structure for the organisation and management of the IRC. A more fluid, networked structure could be beneficial by allowing easier collaboration and movement between and among groups. The new structure should also enable a better balance and synergy between research and teaching as the oversight of these areas will become centralized in a new organisational leadership role, i.e., the Head of School, who will address teaching, research, and engagement from a unified perspective.

It is recommended that the IRC finds additional ways to improve information sharing across groups within the IRC. More frequent meetings of the research group directors could be helpful as could informal occasions where the IRC members have a natural possibility to share their ideas and results.

Engage and appoint guest professors in the research/teaching/impact activities, aligned with the IRC's strategic plans. This will foster further collaborations, as well as better position the centre/school as an internationally-recognised "knowledge hub".

Networks

The School of Informatics is advised to participate formally in relevant international scientific networks. Examples of networks include the iSchools (<http://ischools.org/>) organization, the Association for Information Systems (<http://ais.site-ym.com/>) and the Computing Research Association (<http://www.cra.org/>).

It is also recommended that the research groups more strategically position their memberships in research area-specific networks such as IFIP working groups.

Impact

To strengthen the IRC's impact, cross-cutting themes and possibly projects that address complex and increasingly visible problems in society could be identified. Another approach could be to focus (though not exclusively) on a limited number of areas of impact; e.g., 3 cross-cutting themes that span multiple research groups.

At the IRC level it is beneficial to select and use key performance indicators (KPIs) that are meaningful and relevant to the key stakeholders and highlight the unique strengths of the IRC. The KPIs for success at the individual, research centre, and university levels should be made more explicit. In addition to traditional academic KPIs, IRC KPIs should also highlight the:

- societal/practical impact/spin-off of research activities
- (local) economic impact/contribution of the IRC, and the University in general ("return on investment").

Administrative staff should be tasked with assisting faculty in collecting KPI data.

Take sustainable measures to communicate the IRC's many success stories, on-going activities and vision using multiple media channels to increase the visibility of the IRC and its impact. The need for a more proactive public relations (PR) function is addressed in the University-level recommendations, but this effort will require attention at the IRC as well.

Strategy and development

Jointly create a strategic plan that includes vision, mission, objectives and values. It should be reviewed and modified on a continuing basis. Consider using elements from the Business Model Canvas (tailored for IRC's use) in developing this plan.

Position existing elements in the knowledge-chain (basic research / applied research / impact on praxis), including the role of the research groups, the science park, etc., while also strengthening/extending the support for the elements where necessary.

As a way to increase community building, collaboratively identify and share the core values that the IRC embodies among all members.

Operationalize the IRC goals and values in annual personal development plans, tracking them quantitatively and qualitatively via a template/KPI's.

9.2. Recommendations for the University

Strategy

We see the merging of research and education into one administrative unit as a very positive step. This should facilitate identifying synergies and sharing resources to the benefit of both research and learning. If naming of the new units has not yet been decided we see identifying each unit as a "school" as a positive step.

We encourage the university to use a network model (instead of a silo model) when describing the new organisation. Policies and practices should support linkages between schools if they do not already do so. A social network analysis could be conducted to identify existing, complementary and potential links among schools.

Visibility

One of the support services that should be addressed is public relations (PR). A mechanism is needed to ensure information about the activities of the IRC is captured and disseminated through appropriate channels. The overall PR activity may be centralised at the University level, with an individual with specialised knowledge assigned to the IRC.

Research conducted at the IRC is likely to be of interest to a variety of stakeholders and should be distributed to local and national news outlets, displayed on University and IRC web sites, as well as via social media. Branding and higher visibility for research projects and outcomes would attract additional students, faculty, business partners, and funding.

Support

The University is encouraged to allocate (and fund) a set research time (as a percentage of their overall work hours) for full professors, in much the same way it does for more junior faculty.

We encourage the University to review and when necessary enhance centralised services, including specialised IT infrastructure services and grant support services, to more effectively facilitate research.

9.3. Recommendations for the Government

The research activities of the IRC clearly demonstrate that a new university can produce research that both contributes to the scientific knowledge base as well as provide tangible benefits for the regional economy and to society more broadly. The ability of the University of Skövde to create new knowledge and drive innovation should be acknowledged, and increased financial resources should be made available.

We recommend that at the national level research funding be distributed more equitably among the country's universities. A Balanced Scorecard type of approach that evaluates university contributions on a number of different criteria is recommended. Some of these additional criteria could be quantitative metrics such as regional job creation and number of start-up companies launched.

Acknowledgements

We would like to thank the IRC and the University of Skövde for providing us the opportunity to explore the research at the centre in depth. We appreciate the time and effort everyone at the IRC and the University expended to make this evaluation possible. We would like to especially thank the IRC assessment coordinators, Björn Lundell and Jessica Lindblom, for their help throughout the assessment visit.



UNIVERSITY
OF SKÖVDE

Assessment report

The Systems Biology Research Centre

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1. General assessment of the UoA

The Unit of Assessment (UoA) Systems Biology Research Centre is composed of the following six research groups: (i) the Infection Biology Group (IBG), (ii) the Bioinformatics Group (BG), (iii) the Tumour Biology Group (TBG), (iv) the Physiology, Pharmacology and Toxicology Group (P2TG), (v) the Ecological Modelling Group (EMG), and (vi) the Consciousness and Cognitive Neuroscience Group (CCNG).

The research aim of the UoA is to study biological systems at different levels of complexity (genetic, molecular, cellular and population) using a combination of experimental, mathematical, statistical and computational methods.

The UoA can be characterised as follows:

- it publishes research articles in international and peer-reviewed journals of high impact (319 publications were produced during the assessment period, 2005-2012 of which 220 articles were published in peer-reviewed journals);
- it consists of a unique combination of experimental, statistical, computational and modelling techniques, which makes it very attractive to small and medium enterprises that cannot host such breadth of expertise, such as Viking Genetics AB and Collectis AB. This has led to a considerable number of research projects funded by the Knowledge Foundation (KF);
- it has developed and established robust internal research collaborations between the different groups of the UoA, for example, between BG and TBG, P2TG and TBG, and IBG and BG;
- it has attracted substantial research funding from government agencies (EMG and P2TG) during the assessment period;
- it has trained 20 PhD fellows during the assessment period, yet the number of PhD students per year supervised within the UoA has been decreasing (from 17 in 2007 to 11 in 2012);
- it has created a significant number of research collaborations for its six research groups. Examples are those with University of Göteborg, Swedish University of Agriculture (SLU), University of Krakow, University of Turku and University of Örebro;
- it has an extremely well balanced distribution in gender and age.

The assessment of the UoA, as well as the recommendations of the expert panel, have been based on

- the Self-Assessment Report,
- presentations given by scientific staff members,
- discussions with research group coordinators, staff members, and PhD students,
- visits to the experimental laboratories,
- visit to Viking Genetics AB,
- a presentation by, and a discussion with, a representative of Collectis AB.

1.1 Overall assessment

- SBRC forms a dynamic group of scientists from a wide range of disciplines, ranging from genetics, molecular biology, tumour biology, mathematics, ecology, computer science, philosophy to neuroscience. The coherence of the UoA is mainly due to a common research methodology, characterised by quantitative approaches, bioinformatics and modelling.
- SBRC is an active, innovative and productive research unit.
- The publication and citation record of SBRC is very good, with a number of publications in international peer-reviewed journals of high impact.
- SBRC has found an excellent balance between fundamental, strategic and applied research.
- SBRC has developed and established an extensive network of collaboration with research groups nationally and internationally.
- The research of SBRC is very well embedded in society, due to its innovative research projects in collaboration with private companies and government agencies.
- SBRC has good experimental facilities for carrying out biological research.
- The research program of SBRC is characterised by a large diversity of topics, despite its low FTE available for research.
- SBRC receives, compared to "older" Swedish universities, relatively little funding for research from the Swedish Research Councils. The panel feels that the research of the UoA is of high calibre and competitive enough to be successful and funded by the Swedish Research Councils.
- SBRC has no rights to award PhD degrees. The panel feels that the UoA should be entitled to be awarded this right, given the excellent scientific profile of several SBRC staff members.

2. Quality of Research: **Very good**

The panel rates the quality of the scientific research output as very good. For all 6 areas of research we see articles published in high quality scientific journals.

The Infection Biology Group leads a variety of research projects in T cell immunology, cell fate decision in stem cells, diagnostics of sepsis patients, and regulation of virulence genes.

The collaboration of IBG with the group of Professor Davis (University of Oxford) has led to a number of publications in leading journals. Back in 2005, the group developed a mathematical model to analyse the implications of stoichiometric and affinity differences for protein interactions taking place at the synapse between lymphocytes and antigen presenting cells. These protein interactions are an essential part in the sequence of events that lead to lymphocyte activation and cellular immune responses. More recently, and based on the

previous article, the group has published their findings from the collaboration of IBG with the group of Karolinska Institute led by Professor Arvidson on bacterial pathogenicity. This has allowed the group to study the regulatory network that controls the expression of a gene (spa) and its transcription. This joint mathematical, computational and experimental effort has allowed them to make predictions that could be tested with new experiments. This will allow for the final testing and validation of the mathematical model.

The IBG has shown very good scientific achievements over the last five years. Particularly noteworthy is their contribution to development of mathematical/computational models and bioinformatic tools to understand dynamical processes in immunology and microbiology. In addition, the group has recently developed a special focus on gene expression analysis in stem cell development. This is a novel, possibly therapeutically interesting node. Over the same period, they furthermore focused on developing and applying algorithms for analysis of biological data sets.

In the Tumour Biology group, work of high impact includes examining novel biomarkers, as well as cancer pathways, and thereby providing new insights into diagnosis, prognosis and treatment for different cancer forms. This is of high impact for the development of targeted tumour therapies. Furthermore, a number of cellular and animal models to dissect the molecular mechanisms of endometrial adenocarcinoma and prostate cancer were developed. The focus on miRNA expression on the development of prostate cancer and endometrial cancer is highly welcome and will help in further integration of the group into Systems Biology. Parallel work has identified a gene that is crucial for control of epigenetic mechanisms in endometrial adenocarcinoma. Research is carried out in close collaboration with the Bioinformatics group.

The partnership of the TBG with biotechnology companies as drivers for innovation and a high degree of future synergy has to be commended.

The P2T group has 10 members who are engaged in highly multidisciplinary research combining genomics, transcriptomics, proteomics and other modern molecular biology tools to study biological systems.

A particular strength of this group is research relevant to developing countries in particularly developing methods to reduce human exposure to arsenic through drinking water and eating foods. These research activities are supported by external funding agencies including the Swedish International Development Cooperation Agency (SIDA). This has enabled international collaborations including research collaborations with groups in India and Bangladesh. Publications produced by this group are of international standard. These include a study where computational biology and molecular biology were used to characterize the function of two *Arabidopsis thaliana* genes, ACR2 and PCS1 that could be potentially important for generating new varieties of cultivated crops for avoiding arsenic contamination of human foods.

Other important research activity of the P2T group includes investigating the role of vitamin D in prostate cancer and studies on chronic pelvic pain syndrome (CPPS). The quality of research conducted by this group is of an international standard.

Consciousness and Cognitive Neuroscience group papers are of very good quality and of an international standard, making an ambitious and “cutting edge” programme.

In a well-established middle-ranking journal, Valli and Revonsuo (2009) evaluate their own evolution-based theory of dreaming, finding evidence that is mostly supportive; the paper has been cited a number of times.

In a major paper already cited many times and on a current “hot topic”, Koivisto and Revonsuo (2010) review the literature on event-related potentials and visual awareness, concluding that awareness occurs around 200 ms after stimulus onset. They cite 12 of their own papers among the literature reviewed.

Three other papers report empirical studies by Revonsuo and others: Noreika et al. (2011) showed that when anaesthetics induce brief periods of loss of consciousness various concurrent subjective experiences are reported, contradicting the assumption in the literature that loss of behavioural responsiveness should also lead to loss of subjective experiences. Kallio et al. (2011) found that that an easily-hypnotised person was systematically different from controls on oculomotor tasks, which has implications for accounts of hypnosis. Langsjö et al. (2012) used PET to monitor brain changes during recovery from anaesthesia-induced loss of consciousness. Subcortical systems started up soonest, challenging the assumption that cortical activity is of primary importance in this process.

The Ecological Modelling group has developed an extremely interesting research program. The program is highly novel in terms of scientific approaches, at the same time it contributes significantly to current, and pressing, societal issues, such as sustainable resource management and food production, biodiversity conservation, and disease outbreak control. The unifying characteristic of the ecology program is the modelling approach. The modelling is though firmly based on empirical work and data. The program addresses the various food webs and biodiversity, speciation, environmental monitoring using bio-indicators, commercial fish dynamics, sustainable resource management (fisheries and farming), and disease control outbreaks.

The program approaches these issues in scientifically novel ways, including network analysis, life-history analysis, sympatric speciation, and the dynamics of spatial species distributions.

Although the themes seem quite separate, the panel recognises strong similarities in approaches. For example, network analysis is used in the study on food webs and biodiversity, sympatric speciation and disease outbreak control, and life-history analysis is prominent in the fisheries research and the food web analyses.

The group is remarkably successful in incorporating such analysis in a research program that aims to generate knowledge that contributes to our understanding of societal issues.

The panel was enthusiastic about the presented case-studies that showed how we can understand commercial fish dynamics, e.g., by explicitly including life-history characteristics and/or viewing at population dynamics from a multiple species perspective. The panel finds it interesting that this advanced scientific approach is recognised by the ICES agency, responsible for sustainable fisheries quotas. It is also interesting to see the value of transport network analysis in our understanding of disease spreads.

For the EMG, the SER listed 5 typical papers. The panel notices that all 5 are articles in high-impact journals: Holmgren et al. (2012) has appeared in the ICES Journal of Marine Sciences which is a very applied journal, yet it has a scientific impact factor of 2.5. Jonsson et al.

(2013) is published in *Hydrobiologia*, with an impact factor of 2 (good). Lennartsson et al. (2012), and Norrström et al. (2011) are in *PLoS ONE* with an impact factor of 3.7 and Riede et al. (2009) appeared in *Ecology Letters*, which is at present the top journal in ecology with an impact factor of 17.5! These five papers also are representative for the variety of subjects in the research program of the sub-group Ecological Modelling, i.e. fisheries, speciation, environmental monitoring, spatial network analysis, and food web analysis.

The Bioinformatics group have published high quality research articles in peer reviewed journals with an average IF of 3.30. Examples of journals where they have published their work include *Bioinformatics* which has one of the highest impact factors in this field.

The group has recently published a paper where they demonstrated the potential of a new algorithm that they developed for classification and typing of cancer (Ulfenborg et al. 2013). Their tool performed better than other state-of-the art classification methods. There is good collaboration with other groups within the unit, especially the TBG. Collaboration with the TB group led to the use of their tools to distinguish between normal and malignant tissue in prostate (Carlsson et al. 2011) and endometrial cancer (Karlsson et al., 2009), as well as for survival prediction and for classification of tumours into treatment groups.

The BG is also involved in the study of cold adaption of plants. Here they collaborated with industry (CropTailor) and academics from Göteborg University to study expression of genes involved in cold stress responses in oat, rice, and *Arabidopsis* plants. They have demonstrated that cold stress responses in rice and *Arabidopsis* (Lindlöf et al., 2009) involve many genes interacting in an intricate regulatory network and they rely on the combinatorial control of several transcription factors. The group have developed different algorithms for this work (Chawade et al., 2007).

The central role the BG plays in the diverse activity of the SBRC is clearly evident from the publications. The group also has an impressive track record of interaction with industrial partners.

3. Productivity: Very good

The methodology used in preparing the Assessment of Research and Collaboration statement provided a lot of useful data on the productivity of the UoA. The use of the WoS database for this is highly suitable for Systems Biology, and produces conservative estimates of outputs.

Total volume of scientific publications: the annual number of peer-reviewed articles shows a steady upward trend from 2005 to 2012. The corresponding average impact factor is 3.21 for the articles concerned, which is a high figure. As it is for science journals, it is appropriate to look at the field normalised version of this, which is 1.11 and thus above average for the various subfields involved. These figures should be related to the FTE research staff available to the Centre. Details of FTE research staff are only available for the last two years of the assessment period, but provide an average of 5.35 permanent staff and 14.5 temporary staff, most of whom were PhD students. Inspection of the Tables suggests that these figures are probably a fair estimate for the earlier years. Thus, one could say that, over the 7 year period, roughly 5.6 above-average publications/year/FTE permanent staff or 2.4 above-average publications/year/FTE total research staff were produced. This is very creditable; although the FTE calculation allows for the limited time available to researchers, it does not take into account the difficulty for busy academics of fitting research around their teaching and administrative schedules. Another more direct measure of impact is actual citations. These are presented in terms of the year of publication of the paper, thus tend to decline across years and are difficult to compare with other measures. Nonetheless, the total of 1409 for 7 years is substantial in itself and for the number of publications involved.

The panel is impressed with the number of partners from industry, ranging from 8 to 22 in 2012, and the number of society partners in research, ranging from 5 to 9 in different years. The panel feels that this there is substantial evidence in society of the effectiveness of these partnerships.

Total external funding spend has risen from 4.88 MSEK in 2007 to 8.88 MSEK in 2012, a rise of over 80% in 5 years, and total research funding from 13.09 to 19.96 MSEK, a rise of over 50% in 5 years. Both these figures show real and sustained growth over the period.

PhDs and promotions: over the 5 year period, 20 PhDs were awarded. Given the FTE staff currently available for research, this represents a considerable achievement given the way in which PhD supervision has to be organised (because this UoA does not have the authority to award PhDs in Systems Biology). Although the panel does not have the details, we believe that many of the Systems Biology academic members have supervised at least one PhD student to successful completion. This seems to us a sound basis for allowing Skövde to award PhDs in Systems Biology. The number of permanent staff has been small during the assessment period, so quantitative analysis is limited, but a number of promotions have occurred over this period. The panel does not know the specific criteria for promotion, but research achievements of the Unit would certainly have justified promotions.

Other research outputs of the UoA: a genetically modified plant, a novel bacterium (to remove arsenic or chromium from contaminated water or industry effluents), software, two patents, reference points for fisheries, and database of miRNAs associated with endometrial cancer.

4. Research environment and infrastructure: Good

There is a stimulating scientific environment and an international atmosphere across the UoA. Their research environment and infrastructure is enhanced by the links with external partners, some of which are detailed below.

Leadership: each research group within the Centre/UoA has a strong leader.

The UoA enjoys a close relationship with the Gothia Science Park, which is a great opportunity as they also assist them with making applications for external funding.

Outreach: the UoA has been involved in a large number (on average seven per year) outreach activities, such as popular science publications, in magazines and the web.

The gender and age distribution of personnel is well balanced.

The TBG has within the Centre all the facilities required to be able to develop state-of-the-art research in the context of biomedical research. These laboratories are modern and well equipped. Lab space is adequately organized. There are very good possibilities to access infrastructure at collaborating laboratories.

State of the art laboratories are available for research work in the field of molecular biology and cell biology. The P2T group has set up a well-equipped laboratory for carrying out research work on genetically modified plants. Two PhD students are based in the molecular biology laboratory and are actively engaged in carrying out research to identify genes that are important for arsenic uptake from soil.

The IBG also use the molecular biology labs and have strong links with Collectis AB, as described elsewhere. Collectis provide a stem cell wet lab which is crucial to support this work.

The EMG has less need for laboratories and advanced instrumentation, and good computing facilities are available to support this work.

The CCNG enjoy strong links with groups at the University of Turku, Finland, and most of their empirical data is collected there. There is an aspiration to develop an EEG lab in the Centre to support both teaching and research in this growing field.

The BG use data generated by a number of other groups. Additionally, they need computing facilities with which they are well supplied.

PhD students are trained in the partner Universities. While at Skovde, they have a biweekly seminar series where the seminar schedule is organised by two PhD students, and this responsibility is rotated among the students on a half-yearly basis.

The PhD students use these seminars for practice rounds of their presentations when preparing for their PhD defence. Furthermore, a representative from the PhD students takes part in unit meetings (once per month) where the head of department participates. In addition, they engage fully in teaching. This is good for their development.

There are some infrastructure issues that need to be addressed. These are outlined below.

Too much reliance on facilities based in industry or other Universities is a risk factor that should be considered before the start of any project or the registration of a student. As a long-term strategy, more should be done to establish "in-house" facilities in order to attain greater independence in research. However, at the same time the impressive links with industry and other Universities should continue to flourish.

The UoA cannot award PhD degrees. This makes it difficult to maintain appropriate training courses for their PhD students, who are registered at a different university. Although students are trained in transferable skills through the partner university, the researchers at Skövde have less control over this than if they had examination rights. Therefore, the panel feels that obtaining such examination rights is one of the most important goals for SBRC.

The UoA does not have a mentoring scheme to support the career progression of early career researchers, such as postdocs and assistant professors. Such a mentoring scheme will enhance their research skills, such as writing and applying for research grants, and their career potentials.

Postdocs and other staff with temporary contracts are not allowed to submit research grants as PIs. This is a questionable measure, but it strictly hinders the career progression and independence of researchers at this stage.

A newly introduced regulation does not allow the promotion from assistant professor to associate professor (or Docent) of an academic member of staff, if the University does not award undergraduate degrees in their research area. The panel feels that this regulation severely hinders career progression for researchers at this stage, who are forced to apply for this promotion elsewhere. This might make it difficult to retain junior members of staff, and hurt the viability and sustainability of certain research areas.

5. Networks and collaborations: **Excellent**

There is clear evidence for strong participation of the UoA in national and international academic networks. The unit has research collaborations with 74 institutions where the UoA participates in joint research grants in excess of 100kSEK/year and/or joint publications. Virtually all the groups within the Unit have collaborations with academics in Universities in Sweden and abroad. The academic partners are well integrated into the research activities and contribute with their competence in joint research projects. This includes providing access to specialized techniques and providing training of PhD students. Collaboration exists with a large number of Swedish institutions where students are supervised by members from the UoA. Through this, links have been established with many different institutions, examples of which include Örebro University, Göteborg University, Lund University and Karolinska Institute.

The Infection Biology group collaborates with the Hultgren-Hörnquist lab (Örebro University) and the Davis lab (University of Oxford) as well as Skaraborg Hospital in Sweden. This provides them with access to facilities such as FACS, MACS, SPR, NMR, as well as animal models and patient samples.

The Tumor Biology and Bioinformatics groups have collaborations with researchers at Göteborg University, Orebro University and Sahlgrenska Academy's Cancer Center. This gives them access to research instruments and facilities at these institutions.

The P2T group has collaborations with Universities in Sweden and abroad. This includes collaboration with the Swedish University of Agriculture (SLU), University of Örebro and University of Agriculture in Krakow, Poland. Such collaborations not only provide access to specialised skills and advanced equipment and skills but also the sharing of PhD students and projects that have been productive in terms of joint publications.

For the Ecological Modelling group, the panel sees a very well-developed embedding in networks and collaborations. There are close links with other Swedish universities, (e.g. Linköping, Lund, SLU) and international consortia. The sub-section also takes part in ICES, which the panel sees as a recognition of the value of the modelling approaches developed by SBRC.

The Consciousness and Cognitive Neuroscience group links with a number of strong research groups in University of Turku, Finland.

6. Coproduction and external cooperation: **Excellent**

The Unit has an impressive track record in coproduction and external cooperation. Some of the groups work very closely with industrial partners in joint projects. Funding by KF has been very important here. A great strength of the unit is their co-operation with industrial partners which significantly improves the conditions for and the quality of the research. The synergy created by the collaboration provides an exciting environment for the training of early stage researchers. The students and indeed experienced researchers gain access to state-of-the art technologies which are often not available in academic institutions. Many collaborations have been established, and details of some of the most important ones are given below.

The non-academic partners are well integrated into research projects. For example, researchers from the Infection Biology group work very closely with scientists from Collectis AB. This co-operation led to the granting of two patents on stem cell derived products.

Nordic BioPharma was founded in 2009 by Sandra Karlsson and Dennis Larsson from the P2T group. This company focuses on preclinical immune safety testing without the use of animals. This is a major achievement by the group.

The UoA has developed and established strong links with non-academic partners, such as Viking Genetics (KF research grant with the TBG), InNetics AB, and Collectis (two KF research grants with IBG), for example.

The robustness of these collaborations can be assessed by research outcomes: it has allowed them to recruit new scientists to the UoA, to generate at least two patents, and to establish a biotech company (Crop Tailor AB in 2007). The company develops new oat varieties using high precision methods, such as TILLING.

For the EMG, coproduction and external cooperation focuses on national and international scientific cooperation and participation in fisheries analyses in the context of ICES.

7. Impact: **Excellent**

As described in Section VI, the UoA has established and developed new and exciting industrial and public sector research cooperation activities during the assessment period. Most of the research groups currently work very closely with either industrial partners (Viking Genetics AB, TATAA Biocenter, BioRad, Collectis and MultiD, for example) or government agencies (ICES). The research funding obtained from KF has been extremely important in this respect, as it requires at least two industrial partners per research project. The synergy created by these co-operations also provides an excellent research environment for the training of early stage researchers. Through these multi-sectorial partnerships, both the students and experienced researchers have access to state-of-the art technologies and methodologies, not often available in academic institutions. An example of one such multi-sectorial project is the KF funded proposal on stem cells. Furthermore, the industrial partners benefit from the multi-disciplinary expertise the UoA provides: computational, statistical, mathematical and experimental.

This project brings the UoA together with Collectis and AstraZeneca. Collectis AB is a small and medium enterprise (with about 200 employees), targeted at genome engineering products. It was established in December 1999 and has a strong portfolio: over 120 patents and products in therapeutics, stem cells and targeted cellular medicine. In this project the UoA provides expertise in bioinformatics and modelling. Together they aim to study the proliferation and differentiation program of cardio-myocytes and hepatocytes at the molecular level, with a particular focus to understand the pathways involved in each and every differentiation step. The analysis of gene expression/pathways involved in toxic cellular responses that the UoA is carrying out will be of huge value to Collectis in order to develop a mechanistic understanding of toxicity and the identification of novel biomarkers.

The panel feels that this multi-sectorial research activity has a very strong impact on society, and has the potential to lead to novel approaches in translational medicine.

A second example of cooperation is that between UoA and Viking Genetics AB. This represents a unique collaboration investigating the role of miRNA in bull fertility, which was established with a company (Viking Genetics AB), which is owned by approximately 30,000 farmers from the Nordic Countries. The panel feels that this is clearly a cooperation with exceptional impact on society. Members of the P2T group have set up a company (Nordic BioPharma) which focuses on preclinical immune safety testing without the use of animals.

8. Strategies and plans for development of the UoA Very good

The UoA strategy for the next 2-3 years emerged from extensive discussions with the Panel. The goal is to preserve the diversity of the Centre, while at the same time strengthening the research in a few high profile areas by building on the success of research topics such as the ones shown in the impact cases (stem cells, fish population modelling, tumour development, bioremediation). They plan to produce a dynamic environment that can explore research directions, without suffering from weakness through too much diversity. Specific aims are given below.

To further strengthen the collaborations that have emerged between the groups in the centre during the last few years. (Some concrete examples are mentioned below.)

To apply for (and obtain) the rights to award PhD degrees. This will make the Centre a more stable and more attractive place for scientists to develop their careers.

To apply for funding for an industry-supported graduate school. This will give more stability to the funding of PhD students, which is currently a critical issue and limiting factor.

To obtain KF funding for a research profile. Such funding lasts for 8 years and would provide funding corresponding to up to 10 project grants. Thus, it would reduce the need for smaller 3-year project grants, and it would provide much more stability in the research time for the researchers and more stability to the industrial collaborations.

Once the profile funding is in place, to develop an EU-application. Here it is crucial to take advantage of the strong network of international collaboration that they have built up. Due to the scale and complexity of EU grants, the best strategy is to find a suitable consortium to join.

Examples of new potential collaborations planned within the Systems Biology Centre:

- The stem cell research may enter into collaboration with the cognitive neurosciences as well as with the cancer biologists. There are many promising applications of stem cell therapies in these areas.
- The mathematical modelling could become more integrated with bioinformatics. Thus they would develop more collaboration between the tumour biology, bioinformatics and infection biology research groups.
- The plant toxicity research could develop collaborations with ecology and tumour biology. Arsenic contamination as an environmental problem has impact on the ecology and also causes cancer. It should be possible to form a collaboration spanning from ecological modelling, plant science, toxicology, tumour biology, bioinformatics and mathematical modelling.

9. Experts views on potential and recommendations for development

The panel is very positive about the further future development of SBRC. SBRC has high-quality and enthusiastic staff, thriving research environment, and well-developed networks for scientific and societal cooperation. This is the basis of their present high scientific and societal impact. There is room for improvement, nonetheless, and the Panel has recommendations under several headings.

9.1. Recommendations to the UoA

There is high quality research in all groups, but the size of some of them is too small to be sustainable or achieve international visibility and growth. Therefore, careful attention should be made to ensure a critical mass.

SBRC should focus on developing areas of strength, and look for linkages between their present quantitative and modelling approaches to ensure their position as attractive partner for cooperation with industry, governmental agencies and the national and international scientific community.

Concerning future activities in the miRNA field, the panel recommends a joint effort with other groups at the expense of lower priority programs. The Centre recently initiated its own efforts on gene expression analysis in stem cell development, an activity which needs to be carefully aligned with other activities of the Infection Biology group.

It is recommended that a mentorship scheme is introduced to support early career researchers and newly recruited staff so that they can effectively develop their research skills and potentials.

9.2. Recommendations to the University of Skövde

Whilst applied research is a particular strength of the SBRC, there is a clear need to provide support for basic research so that this continues to improve.

Full support should be given to the scientists within the unit so that a strong application can be submitted to the government to obtain the right to award PhD degrees. This is important considering the excellent track record of the scientists and their role in successful supervision of PhD students registered at other institutions.

The scientists within the unit are highly competent and have international reputation in research and teaching in their field. Therefore, the University should give them more autonomy, involve them in decision making processes, such as recruitment of new staff, and where possible take steps to support potentially risky blue sky research.

Currently, the scientists within the unit are heavily reliant on a limited number of funding sources, especially KF. This is risky since changes in the funding criterion of KF foundation may lead to a substantial reduction in income. Therefore, the University should facilitate diversification of sources of funding as a long-term strategy.

There should be further support for research with commercial significance, especially those topics with wider relevance to society such as improving public health and the environment. An active research and commercial office within the University is needed to support researchers with application for grants, filing patents, technology transfer, finding industrial partners etc. Special support for increasing the number of grant applications made to the European Union should be in place.

Improving the career paths of early stage researchers and better funding for their research and development should be a priority.

The media and communication departments of the University should be utilised to support researchers to publicise their work beyond the academic circles, regionally and internationally.



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Assessment report

The Virtual Systems Research Centre

Viggo Tvergaard, Technical University of Denmark, Denmark

Heiner Bubb, Technical University Munich, Germany

Costis Kompis, Vodera, UK

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1. General assessment of the UoA

This report captures the assessment of the Virtual Systems Research Centre carried out at Högskolan i Skövde, between the 8th and 13th of September 2013 under the ARC13 process. The ARC13 review was professionally organised. Staff at all levels were extremely open about the Centre's activities, providing access to facilities and responding promptly as requested.

While the focus of this assessment is on research, the Centre is heavily involved in teaching. There is good cohesion in the teaching within the three-year Bachelor programmes of Maskiningenjör, Designingenjör and Produktionsingenjör undertaken cooperatively by the Centre participants.

The Panel reviewed the work of the Centre and its three groups, namely, Mechanics of Materials (MOM), User Centred Product Design (UCPD) and Intelligent Automation (IA). The poster session worked particularly well giving the Panel the opportunity to meet the individual researchers from the groups and discuss their work.

The overall impressions from the review of the Virtual Systems Research Centre include the following.

- The researchers are strong and enthusiastic and conducting very good, relevant and recognised research.
- All groups provide significant input to the teaching enterprise.
- All groups share an underlying thread in the area of manufacturing.
- The connection between the name of the Centre and activities of the groups is not always apparent. This may be due to historical reasons.
- The researchers are clearly supportive of one another, yet there are few joint projects.
- Respectable research outcomes have been achieved despite the relatively limited resources.
- There are few strategic collaborations or partnerships with renowned research groups probably due to the short history of the Centre and its small size. Developing such collaborations is of paramount importance.
- There is evidence that the research meets demands of industry, particularly local industry.

Regarding the ranking criteria, the Panel found:

- The Quality of the research, Research environment and infrastructure, and Impact are characterised as 'very good'.
- There is room for improvement in Productivity, Network and collaborations, and Coproduction and external cooperation, which are ranked as 'good'.

2. Quality of research

Overall

The reach, quality and impact of the fourteen full time equivalent (FTE)¹ research staff vary across the three groups with a range of contributions to the field as well as publications in journals and conferences. Some challenges related to intellectual property and the associated problems with publishing in a project-based environment were noted.

At this time, there are 18 Ph.D. students enrolled in the Centre, two of which are industrial Ph.D. students. Historically, only a few Ph.D. students complete their programme each year. This is a result of the inability of the Centre to directly award Ph.D. degrees and the requirement to have another university award the doctorate degrees. This may deter prospective graduate students from enrolling at Skövde. Nevertheless, it is recognized that the academic staff in the Centre contribute significantly to the supervision of the doctoral students.

All three groups in the Centre have demonstrated the ability to publish in quality journals and conferences within their respective fields. The groups maintain some specific international collaborations. There is evidence that the research, through the industrial partners, results in a broader application in the relevant industry.

Mechanics of Materials (MOM)

The Mechanics of Materials group focuses on solid mechanics of light weight structures. Its research is on the leading edge of the understanding of adhesive behaviour. Further, the group studies the mechanics of composite materials - a highly competitive area.

The group has a record of publishing in respected international journals.

User Centred Product Design (UCPD)

The User Centred Product Design group assesses the role of digital human models in industrial applications from a fundamental knowledge of ergonomics. The research within the group is timely and of high quality.

Publication in good journals is part of the output, however more emphasis has been placed on dissemination in good conferences. This may be an appropriate venue in a developing field especially given the project-based nature of the work.

Intelligent Automation (IA)

The Intelligent Automation group focuses on multi-objective optimisation mainly applied to assembly, production and logistics. Their research takes place within the context of operational research and has been recognized nationally through a best paper award.

The work of the IA group has been reported in both respected international journals and conferences. Again, conferences may be an appropriate venue in a developing field especially given the project-based nature of the work.

Grade: Very good

¹ 2 Professors, 5 guest professors at 20%, 3 associate professors and 8 assistant professors.

3. Productivity

Publications

The indicators for productivity are given in tables at the end of the ARC13 report for the Virtual Systems Research Centre.²

The total number of publications between 2005 and 2012 (Table B2.2.1) was 341. According to Table B2.2.6 the ratio of the number of all publications to FTEs is 3.66³.

There were 65 peer-reviewed journal articles between 2006 and 2011 (Table B2.2.1). These 65 gave rise to 357 citations (Table B2.2.3). The ratio of citations to peer-reviewed journal articles is 5.5.

Promotions

As stated above only a few Ph.D. students complete their programme each year.

The development of scientific staff (Table B2.1.1) from Ph.D. to Docent and to Professor is dependent on historical hiring practices. There have been only a few promotions during the period considered (2007 – 2012).⁴

Grade: Good

4. Research environment and infrastructure

According to the literature provided, about every fifth resident of Skövde has undertaken university-level education. Obviously, Högskolan i Skövde (HIS) plays an important role in the community. The region surrounding the university includes agricultural lands and local industries. The industries in the area provide employment and several, such as Volvo, collaborate with the Centre. The Panel notes that HIS is a *Volvo Global Preferred Academic Research Partner*. The Centre also has collaborations with industries further away, for example, Scania in Södertälje and Saab Aeronautics in Linköping.

The Centre is well connected to local industry, some with exports in international markets. The issue of intellectual property was discussed but agreements are in place to address this challenge. The supporting industries speak highly of the usefulness, relevance and impact of the developments of the Centre.

The proximity of the Gothia Science Park offers opportunities in terms of collaborative and cross-disciplinary developments. During the review of the Centre some evidence of exploitation of the relationship was presented.

The laboratory space used by the Centre combines undergraduate, graduate and research space as well as dedicated research space in both Portalen and Building G. The Expert Panel was told that space currently used for demonstrations etc. will be converted to new research space for the UCPD and IA groups.

² The Expert Panel has not used the Norwegian method since the Norwegian impact factors are not consistent with recognized impact factors given to various publications by the Web of Science, for example.

³ It is not clear if the number of FTEs used in Table B2.2.6 is the same as the number given in the meetings with the Centre.

⁴ The Expert Panel noted that there is only 1 W in Table B2.1.1.

The Panel observed the following.

- MOM's test facilities are limited to a physically small space.
- UCPD needs the capacity to capture human behavior and properties; e.g., with cameras, motion capture, body scanner etc.
- The IA group needs more visualization equipment.

Grade: Very good

5. Networks and collaborations

Some national and international academic collaborations have been established. For example, connections are seen nationally with Chalmers (MOM and UCPD) and Jönköping (IA) and internationally with the Fraunhofer Institute Bremen, Germany (MOM), DTU, Denmark (MOM), De Monfort University, UK (IA) and Loughborough University (UCPD).

Part-time professors associated with the Centre can be found nationally with KTH and Karlstad University and internationally with Michigan State University, USA and in the UK, with Falmouth University and Loughborough University.

Further collaborations with established research groups will be needed to better position the Centre in the future.

Grade: Good

6. Coproduction and external cooperation

All three groups within the Centre have active connections to local, and by extension, international industries. The transfer of knowledge and technology to industry speaks to the competence and relevance of the research work and the success of the various research-industry relationships.

The Unit of Assessment provided a number of examples of collaboration with society except academia. These include, but are not limited to the following.

- Methods to measure cohesive properties developed by MOM are now used by Saab Aeronautics and the adhesive manufacturer Sika.
- A digital human modelling process developed by the UCPD group has been adopted by Volvo Car Corporation for application in handling ergonomics simulations within production development.
- The IA group has applied its iCan platform to optimise routes for garbage collection and handling in collaboration with the regional company Avfallshantering Östra Skaraborg. Initial evaluations show significant cost savings for the end-user. In addition, the IA group has seen the adoption of some research results by Volvo Cars.
- Teaching topics informed by industrial requirements along with development of undergraduate laboratories; e.g., the Lean Lab, demonstrate a good connection to the local industry.

Tenants of the Gothia Science Park (Gothia Innovation AB) have started to engage in knowledge-exchange activities with members of the Centre.

Grade: Good

7. Impact

The impact cases presented by the Centre are Holistic Simulation Optimisation and the Strength of Adhesive Joints.

Holistic Simulation Optimisation

The FFI-HSO project was initiated with the aim to explore and develop a new management and decision support methodology (HSO). The success of the HSO is demonstrated by a business case study completed at Volvo Car Corporation (VCC). This resulted in the nomination of the work by VCC for a 2013 Volvo Cars Technology Award. In addition to other publications arising from their work, the Group has received two best paper awards, one from a Swedish production symposium (2012) and one from a conference in Catania, Italy (2013).

Strength of Adhesive Joints

The MOM group has an established record in the study of the strength of adhesive joints. The research work in the MOM group has been recognized by Saab Aeronautics and Sika, among others. The methods developed by the MOM group address industrial needs, and as a result reduce both the number of required experiments and the associated industrial costs. The publications listed in the case study include several in some of the best international journals.

Grade: Very good

8. Strategies and plans for development of the UoA

The three groups in the Centre share an underlying thread in manufacturing and share common teaching responsibilities. However, there are cases where there are rather strong connections to the other Centres. For example, the IA group in the Virtual Systems Research Centre has ongoing collaboration with the Informatics Centre including the graduation of one of their Ph.D. students through the Informatics Ph.D. programme.

The use of the term Centre when applied to their research areas is unclear in this case. A centre suggests a synergy provided by cooperation and trans-disciplinary efforts. In the Virtual Systems Research Centre the research efforts may share an underlying thread but the MOM, UCPD and IA groups function largely as solitary entities. The term Virtual is confusing and ambiguous while the term Engineering may better reflect the scope of the research work.

The researchers in the Virtual Systems Research Centre are located in the same building, namely Portalen. The laboratories for UCPD and IA are also in Portalen however the research lab for MOM is separated physically by its location in Building G. The planned extension of

the UCPD and IA laboratories into space on the ground floor of Portalen will promote growth of the Centre. New research initiatives will be available to both junior and senior faculty. The Panel notes that the three-year funding model associated with the Knowledge Foundation limits the planning horizon of the Centre and is a detriment to the development of longer term Ph.D. studies.

The planned restructuring of the departments within the university as well as the upcoming release of the results of the national assessment of engineering programmes may affect research as the individuals in the Centre may need to respond to demands at multiple levels.

Grade: Good

9. Experts views on potential and recommendations for development

To date the Centre has depended strongly on funding from a limited number of national sources which require matching support by industrial partners. Due to the high variability of the funding, diversification of research income is necessary. The Centre needs to develop mechanisms to access a wider range of financial opportunities.

With the support of a manager experienced in EU or similar applications, and in handling industrial relationships, the researchers in the Centre could expand their activities. Also, consultancy, funded-research, studentships, corporate donations, matched funding, and so on, could be used effectively to provide a relatively stable cash flow thus improving the effectiveness of the funding and the success of collaborations.

9.1. Recommendations to the UoA

The Virtual Systems Research Centre is not yet well recognized in an international context. This presents challenges in determining the way forward. The industrial relevance and support of their research work is important. Receiving national and international recognition is critical. The available human and financial resources needed to respond on both these fronts are limited.

Strengthening academic visibility

- Publication of research work in high impact journals is an accepted and well-understood measure of academic success. Consideration should be given to finding the right balance in publication for each group in the Centre.
- Extra effort is required to establish new collaborations with external centres of excellence.

Strengthening knowledge exchange activities, with particular emphasis towards industrial audiences

- The Centre needs to creatively seek opportunities to communicate their research results to potential collaborators and sponsors. Success stories need to be

continuously identified and promoted. Other effective channels can include Showcase events where industry can see and feel the research work and identify new applications and form partnerships.

Administration

- Review of the structure of the Centre is needed. One aspect for consideration is whether additional engineering disciplines should be incorporated in the Centre.
- The need for the support by a manager experienced in EU or similar applications should be addressed. Experience with handing or managing intellectual property rights is also essential. Access to services to support these issues could perhaps be obtained from Gothia Innovation AB which is located close to the Centre.

9.2. Recommendation to University of Skövde

- The Five Units of Assessment considered in the ARC13 programme function, to a large extent, independently. Nevertheless, there are areas of interest that cross the units of assessment. While common areas might be noted and exploited, they present challenges. For example, if a student or a professor moves between Centres, funding will be affected. This can inhibit mobility and knowledge transfer. There may also be merit in exploiting synergies across their research subjects.
- Seed funding for transitions in topics or new exploratory work may be useful in strengthening the mobility of researchers. This can be secured by requiring a small percentage of all incoming funding to be allocated for this purpose.
- Vertical integration of the educational pipeline is a normal outcome in a mature university. The pipeline of students from the three undergraduate degrees (Maskiningenjör, Designingenjör and Produktionsingenjör) to the Master's and Ph.D. programmes is small. Some very good students are retained however recruitment of other Swedish students is necessary and the graduate programmes rely on international recruitment. The recent re-introduction of the Master's in Solid Mechanics (Tillämpad mekanik) is welcome as it re-establishes the pipeline from the Bachelor to the Ph.D. levels in solid mechanics, even if the Ph.D. is granted by Chalmers University. The Panel supports the planned addition of another Master's programme in 2014 or 2015 and proposes that the existing Industrial Ph.D. programme be expanded.

9.3. Recommendations to the Swedish government

The Virtual Systems Research Centre in Skövde has excellent interactions with large industries locally and nationally. Therefore it is in the national interest to continue and enhance the Centre's activities.



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Self-assessment

Enterprises for the Future

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ARC13 – Evaluation Package

Introduction

The following document describes the research and collaboration of defined units of assessment (UoA) at the University. The document includes indicators on research activities, research initiatives and collaboration in research in relation to academic, business, or public partners. The document also includes a qualitative self-assessment of the strengths, weaknesses, opportunities and threats (SWOT) of the UoA. The indicators aim to describe research activities in specific areas as well as in multi-disciplinary fields. Apart from direct research quality assessments, a number of different aspects are requested to be elucidated; description of the research field, research environment and infrastructure, research output, impact, engagement and co-operation with society (which in this document denotes organisations within business and public sector, non-governmental organisations, the public, but not including other academic institutions) and opportunities for renewal and actions for successful development. The document also includes two case descriptions identified by the UoA as particularly important or significant (see C). The document is structured in three parts:

Part A – Strategic information about the UoA (general description and SWOT-analysis)

Part B – Quantitative data describing the UoA (general information, research output and co-operation with society)

Part C – Case descriptions (two impact cases)

The parts are complementary. Information provided in either part should be used to support and deepen the information presented in the other.

ARC13 generally assesses the period January 2007 to the end of December 2012 (see appendix 1), although some of the indicators cover a shorter period of time. The expert panels are asked to assess the quality of research (and collaboration) at the UoA in an international perspective based on the instructions given in the *Terms of reference* (Appendix 1). In particular, the panels are asked to identify **strong research activities, strong collaboration with society** and **potentially interesting opportunities for development**.

Part A: Strategic information from the unit of assessment (UoA)

In this part of the evaluation package the UoA communicates information on organisation, co-operation and strategies chosen to ensure that relevant, high-quality research is conducted.

Table 0 – Name of the UoA	
Name of Unit of assessment	ENTERPRISES FOR THE FUTURE
Coordinator of Unit of assessment	Stefan Tengblad

A1. Description of the research in the UoA

This is an overview of the current research areas, including primary missions and goals, within the UoA. (Max 4 pages, in template format):

Enterprises for the Future is a research centre initiative under formation at the University of Skövde. As the centre was not in existence during the evaluation period, this evaluation emphasizes the following: the centre’s main conceptual ideas, internal organization, planning process, funding opportunities, research infrastructure, and the competence and productivity of its scientific staff. As a nascent research centre, some areas have not had the opportunity to fully develop their activities or to publish the results of their research. In addition, owing to the forward-looking aspect of the evaluation, we do not identify certain researchers or their work. These are researchers, no longer employed at the University, who were active in our faculty in the years 2007-2012. We also exclude publications by current researchers (recently recruited to our faculty) that were published under other universities’ names. Therefore, for these reasons, our publications list is shorter than it would have been had the centre been fully operational in the evaluation period.

In April of 2011, Rector Sigbritt Karlson (University of Skövde) proposed an initiative for a research centre to be named Framtidens företagande (English translation from Swedish: Enterprises for the Future). She asked Professor Stefan Tengblad to investigate the possibility and desirability of forming such a research centre. In May 2011, Professor Tengblad sent his investigative report to the Rector Karlson, which she made public in the autumn of 2011 (Tengblad 2011).

In October of 2011, Professor Tengblad was asked to identify research groups (and leaders) that had an interest in participating in the Enterprises for the

Future initiative. This assignment, completed and reported in December of 2011, was instrumental in the decision to include the initiative for the research centre in the University's development plan.

In 2012, as preliminary work on the initiative continued, structures were created and research groups were formed. Gradually, as the research groups crystallized, there were several internal and external presentations and a series of research seminars that explained the centre's goals and concepts. At year-end, the decision was made to include the research initiative in the ARC13 evaluation.

Main research areas and priorities

The research groups (and their researchers) provide the foundation for the research centre. The three main research areas are the following:

- **Internationalization processes.** This area deals with how SMEs acquire international experience (export, operations, etc.). Theories on internationalization are used in the research.
- **Strategic and entrepreneurial change processes.** This area, which takes a resource-based view of the enterprise, examines strategic development processes and the roles of HRM and entrepreneurship, primarily in small manufacturers.
- **Leadership and process development.** This area is concerned with the development of various organization processes and capabilities. The role of leaders and the function of leadership are examined in connection with these processes.

More details about these research areas and the related groups are presented in the group level documents.

The mission of the research centre and its theoretical underpinnings

The mission of the research centre is to conduct innovative research in entrepreneurship, business studies, public services and related subjects, all in connection with various kinds of enterprises. We interpret enterprises broadly. Although private sector enterprises are an important area of our research, we also study public sector enterprises. In some ways the two groups provoke similar research interests; for example, resource constraints, leader and follower issues, and external competition. Today, a municipal primary school or a community sports club faces competition much as private companies do. Most organizations nowadays compete for customers, pupils, and visitors. The

term “enterprises” is appropriate because our interpretation of research on enterprises encompasses many human activities, responsibilities, and relationships.

Here we describe two reasons for the choice of “For the Future” in the centre’s name. First, we are calling attention to enterprises’ forward-looking goals and operations and to the importance of their preparation for the future in their on-going activities. Second, we are emphasizing enterprises’ ethical responsibility for the future of society in its multiple aspects (e.g., the environment, work life, human rights). We find it interesting (and challenging) to study how entrepreneurial actors conceive of their futures and how these conceptions influence their actions. As Strobel et al. (2013) writes, the future is shaped by the way we act today. Proactive behaviour that considers environmental and social issues increases our chances of making the world a better place.

Evolutionary theory provides the theoretical underpinnings and inspiration for the research centre (see, e.g., Aldrich, 1999). According to this theory, which acknowledges the large dynamics at work in the population of enterprises, the leading companies in one decade are often overshadowed by other companies in the next decade. Evolutionary theory, as applied to enterprises, is based on three important concepts: variation, selection and retention. The modern economy produces constant variations; some of these variations are selected and some that are selected are retained over time (retention). In our research on the future of enterprises, we focus on how enterprises choose, develop, and sustain various processes as they seek to realize their objectives.

Evolutionary theory has several important implications for the research group “Strategic Entrepreneurship”. Entrepreneurship as a research topic leads to analysis of the variation dimension of the evolutionary framework. Enterprises that are unable to create variation (through entrepreneurship) or to react (by adaptation of strategies to new situations) are not “selected”. They are eliminated from the population. This group also uses the resource-based theory of sustainable competitive advantage to explain the retention elements in evolutionary theory.

The research group “Leadership and Process Development” also uses evolutionary theory in its investigation of how leadership supports, and is supported by, the three stages of variation, selection and retention. The theory is also applicable in the group’s research on how process development influences variation, selection and retention. The fundamental assumption of this group’s research is that the traditional leadership research overemphasizes the role of the leader. By contrast, the group argues for a more relational and processual view of leadership that focuses less on structural elements and

rational planning, and more on the relationships and activities of leaders and other enterprise members. In particular, the group uses evolutionary theory in its study of emergent action.

“For the Future” in the centre’s name has yet a third purpose. We are declaring our interest in the uncertainty and unpredictability that are natural and unavoidable features in the enterprise landscape. Decisions typically involve unknown outcomes, and actions often take unexpected courses. Therefore, enterprises must be flexible knowing that such is the nature of their complex environments. Dealing with such complexity is a crucial challenge for many enterprises. Therefore, rather than rely on simple, standardized techniques, enterprises should use technical, economical and social resources (especially human competences and learning) to devise holistic solutions to problems.

The three research groups at the centre find that Cameron and Quinn’s (2011) The Competing Values Framework (collaborate, create, control and compete) is a useful model for their empirical research (especially for case studies). The model is suitable for understanding and diagnosing the complexity caused by the uncertainty and unpredictability of enterprise life. For instance, one research group has experience with the “collaborative” paradigm. The other two research groups have experience with the “control” and “compete” paradigms. All groups aim to acquire larger experience with the “create” paradigm.

Because Enterprises for the Future is still in its formative stage, its internal coherence is not yet systematic. A task of highest priority is to strengthen the internal alignment of the various research activities in order to take advantage of group synergies and collaborative opportunities. A common goal of the three research groups is to understand and investigate the contextual factors that influence the development of enterprises as entrepreneurs and managers cope with their work challenges.

To summarize, Enterprises for the Future is a multi-disciplinary research initiative that, in taking a multi-paradigmatic perspective, seeks to understand strategic processes in the private and public sectors. The research focuses on the strategic processes that have implications for the future of enterprises as well as the future of society. These processes are, in particular, the change and innovation processes enterprises are involved with as they prepare for a complex and uncertain future.

The specific theoretical frameworks and projects for the three research groups are described in separate documents.

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A2. Summary of the scientific results

This qualitative summary of the most important scientific results of the UoA should reflect the width of the research and make reference to no more than 30 publications (Table A2.1) and other research outputs (Table A2.2). The summary should include comments to the publication and citation profile as presented in section B2.2, including the coverage of output from staff no longer affiliated to the UoA.

Table A2.1. Selected peer-reviewed publications¹

1. **Abraha, D., & Hyder, A-S.** (2009), From Industrial Networks to Strategic Alliances or Vice-Versa, *Journal of International Business and Emerging Markets (IJBEM)*, 4, 361-386.
2. **Abraha, D., Osarenkhoe, A., & Awuah, G-B.** (2008), Relationships and Networks in the Processes of Establishment of Firms in Transitional Economies –The Case of Scandinavian Firms in Eastern and Central Europe, *International Journal of Strategic Management (IJSM)*, 1(8). 25-44.
3. **Abraha, D., Zineldin, M. & Vasicheva, V.** (2008). Establishment Processes and Building Relationships in Latin American Countries – The Case of Swedish Firms in Mexico, *International Journal of Automotive Industry and Management (IJIAM)*, 2(1), 23-47.
4. **Andersén, J.** (2007a). How and what to imitate? A sequential model for the imitation of competitive advantages, *Strategic Change*, 16(6), 271-279.
5. **Andersén, J.** (2012) Protective capacity and absorptive capacity: Managing the balance between retention and creation of knowledge-based resources, *The Learning Organization*, 19(5), 440-462.
6. **Andersson, T.** (2008). Personal growth and sensitivity training - Fashions in

- management and management research, *International Studies of Management & Organization*, 38(2), 61-82.
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¹ Publications should be listed in Harvard format. DOI=The Digital Object identifier system, for scientific publications is added in the following format: DOI: 10.1016/j. tibtech.2007.05.002 As a service for the expert panel, the listed publications are available to the expert panel as pdfs. Where the publication takes the form of a book, two copies should be provided.

Overview of research results

Table A2.1 lists 30 international publications consisting of 26 articles in blind-review journals, 2 books, 1 book chapter and 1 conference paper proceeding. These publications present an overview of the scientific results from the research initiative, distributed evenly throughout the evaluation period. These publications were selected as representative of the three research groups: Group 1: 8 publications; Group 2: 7 publications; Group 3: 15 publications. Group 3 has the most publications because it has the most members. The individual group documents present more information about their scientific contributions.

Research outcomes from Group 1: Internationalization and Social Entrepreneurship

Group 1 was formed in 2012 and began formal operations in January of 2013. However, due to reorganization at the University, the researchers in the area of Social Entrepreneurship left the group in April of 2013. However, some researchers in this group are still interested in Social Entrepreneurship and intend to develop it as a research specialization in the next few years even though those who were first responsible for the work have left the group. Thus, we are unable to write a great deal about Social Entrepreneurship in this report.

Group 1 primarily investigates how firms can use their resources efficiently and effectively in collaboration with their partners in order to develop and sustain their competitiveness. Using resources effectively and creating competitive advantage require learning and developing new methods, processes and techniques for operations. This means that business organizations have to be creative and innovative. This competence, which is explained in terms of creativeness and innovativeness and its results, helps ensure firms' survival and success in the future.

The eight peer-reviewed articles were published in eight different journals. The articles deal with internationalization, foreign market establishments, strategic alliances, developing and sustaining competitive advantage in industrial markets and marketing in general, CSR and the choice of Export Based Strategy or Manufacturing Establishment. The articles were published in journals such as the European Journal of Marketing, Journal of International Business and Emerging Markets, International Journal of Strategic Management and Journal of Business Ethics. The articles and the journals are of high quality according to external evaluators. The articles were used in promotion evaluations for the authors and contribute to the theoretical development in the field of international business. Examples of this are the role of independent actors in interconnected networks, the role of personal networks in strategic alliances and the globalization of national business systems.

Research outcomes from Group 2: Strategic Entrepreneurship

Group 2 was formed in December of 2012. Thus, as the group is newly established, the quantitative data in this evaluation as of June 2013 do not necessarily represent the research output of the researchers currently in the group. The group is interdisciplinary and consists of researchers in, for example, strategic management, entrepreneurship, management accounting,

marketing, and engineering. The Strategic Entrepreneurship group currently consists of 11 researchers, including 3 associate professors.

The members of Group 2 share an interest in strategic entrepreneurship. Researchers in Strategic Entrepreneurship seek to combine research on opportunity-seeking (i.e., entrepreneurship) and advantage-seeking (i.e., strategic management) in order to explain sustainable firm performance.

The publications by Group 2 indicate the group's interdisciplinary character. The publications also indicate the group's common denominator (i.e., an interest in organizational, entrepreneurial and strategic change). The three articles published in journals with highest impact factors are Ljungberg (2007), Linderoth (2010) and Tekmen et al. (2008) (2.2, 1.5 and 1.1). Andersen (2012) is published in a journal rated as a top journal (Level 2) in the Norwegian list. Jacobsson and Linderoth (2010) is published in a well-regarded journal in the ABS list, and Linderoth et al. (2011) is a frequently downloaded conference paper from a prestigious conference.

These publications, which take a holistic approach to business, deal with various change processes. For example, Ljungberg (2007), which is about the process of product development, examines this issue by considering the selection of materials as well as product design and sustainability. Linderoth et al. (2010) take a holistic approach by applying a network perspective. Andersen (2012) and Andersén (2007a) concern the development and retention of strategic resources. Jacobsson and Linderoth (2010) and Linderoth et al. (2011) deal with the need to consider external factors as key arguments. Thus, these publications all concern various forms of change viewed holistically.

Research outcomes from Group 3: Leadership and Process Development

Group 3 is a multi-disciplinary research group that was established in the autumn of 2011 (under the name Leadership and Organizational Resilience). The group consists of researchers in Business Administration, Logistics, Social Psychology, Law and Technology.

The central goal of Group 3 is to understand how enterprises create their futures. The theoretical model for this group is the evolutionary approach that uses the terms variation, selection and retention for understanding enterprise development. A fundamental premise in the research on Leadership and Process Development is that the importance of the leader's role is typically overestimated. Research outcomes of Group 3 are in several fields.

Leadership and process development in healthcare: Group 3 has published several peer-reviewed articles. In their publications, patient-centred care is problematized by revealing that actions intended for patient-centred care can have the opposite effect. For instance, if the risk to the patient is transformed to a perceived risk for physicians and healthcare managers, they will be more concerned with personal risk (of failure) than with patient risk (Andersson & Liff, 2012a). A related point is made in (Andersson & Liff, 2012b), which emphasizes that increased accountability is only fruitful if it goes hand in hand with responsibility development. If the focus is limited to accountability, actions that “protect one’s own back” do not lead to increased responsibility.

Managers’ work and identity: There are four peer-reviewed journal articles and one anthology in this area. The Work of Managers is an 18-chapter anthology published by Oxford University Press, edited by Stefan Tengblad (2012). The book has 13 empirical chapters, including one by Tengblad on different kinds of managers, as well as several theoretical chapters. The four peer-reviewed articles address managerial identity in different ways. One article focuses on the interrelationship of fashions in management and research that influences the identities of managers and researchers (Andersson, 2008). Another example is Andersson (2010) that describes the difficulties managers have in “being” stable and predictable leaders while, at the same time, in an environment of continuous change, they are also “becoming”.

Leadership and process development in the retail industry: The research in this area has mostly been published in Swedish. However, we have also published in English, and more English language articles are planned. In Andersson et al. (2012) the authors focus on retail work and retail leadership in Sweden that differ greatly from that of most other countries. The authors conclude that the Swedish work-life values between managers and co-workers – cooperation, trust and responsibility-sharing – have influenced the Swedish retail sector more than the logic of the international sector. As a result, managers and co-workers in Sweden’s high-performing retail industry are more content than retail workers elsewhere.

Process development in logistics: The research conducted and published in logistics takes this holistic view in its study of logistic process development in Supply Chain Management (third-party logistics integration), automotive production (Volvo Case, and semi-autonomous vehicles), and in distribution

systems (deregulation of railroads, and traffic-flow analysis). A few examples are given below. Jäger et al. (2007) present a rather new actor-type whose governing business idea is flexibility. Such integrators, who do not own infrastructure, specialize in coordinating and managing customers’ logistical flows using third-party logistical providers. This study, which offers insight into "state-of-the-art" logistics for managing complexity, represents a mature example of process development. Two distribution-related articles are in part a study on predicting future trends and needs in the distribution of major traffic flows. In Hilmola et al. (2010) the researchers describe a survey of the largest companies in the Nordic countries and their prospects in Asia and Russia. In Hilmola et al. (2007) the authors compare three widely different approaches towards railroad privatisation that have taken place in the USA, the UK and Sweden.

Table A2.2. Other major research outputs ¹			
Type of output	Main person responsible	Description	Date when became publicly available

¹ There is a maximum number of research output submissions allowed. The number of key research outputs, whether publication or other research output, is limited to the total number of professors within a UoA multiplied by four. The number should be four in case the UoA does not have a professor. Internationally acknowledged research outputs such as new materials, products and processes, patents, software, computer code, standards documents, evidence synthesis including systematic reviews, analyses, meta-analyses, research-based clinical case studies that add new knowledge, physical artefacts such as images, materials products and processes, prototypes, digital artefacts such as datasets, software, film and other non-print media etc.

A3. Research environment and infrastructure

In this section, the UoA presents the research environment that constitutes the context and breeding ground of its research.

A3.1 Organisation of the UoA

A description of how the UoA is organised; how research is managed and quality-secured; a presentation of research groups; how efforts of fund-raising are structured. (Max 2 pages for UoA and an additional ½ page per group)

As mentioned, the research initiative Enterprises for the Future is organized into three thematic research groups: Group 1: Internationalization and Social Entrepreneurship; Group 2: Strategic Entrepreneurship; and Group 3: Leadership and Process Development. Each group is multi-disciplinary and consists of members with different research competences. One organizational principle of the initiative is that at least two members in each group are full professors or one academic step below. The goal is that these members should be qualified to act as research group leaders or deputy group leaders. We have met this goal in two groups. At present, there is only one professor in the third group because of the reorganization of the University's research organization.

The supervisory board consists of the following members: the research group leaders and their deputies, Stefan Tengblad (the centre leader) and Tomas Müllern (Guest Professor from Jönköping International Business School). The board meets 4-5 times a year. During the school year there are monthly joint research seminars (about 8 seminars a year). A doctoral student announces and coordinates the seminar series with support from the centre leader.

Because at least one group is still in the formative phase, we realize we need to strengthen the unity and cooperation among the groups and within the centre as a whole. With respect to this research evaluation, we plan to hold coordination activities in September (2013) at the time of the Evaluators' field visit and later in the autumn with our research colleagues at the University of Borås. More information about the organization of the groups is the group documents.

A3.2 Personnel

Present a general analysis on staff related to personnel tables in section B1.1 (Max 1 page)

The Tables in Section B1 were prepared by the University Administration and include only those individuals with research required as part of their assigned duties. A problem at the University exists because too few teaching staff members are required to conduct research. Nevertheless, several members of the teaching staff without research duties are actively engaged in research.

The table below lists 40 persons employed by the University with Enterprises for the Future as their research affiliation. Of these, almost 50%

have a doctoral degree and 25% have the competence to act as a research leader.

Members in the research groups: as of June, 2013

	1: Int & Soc Ent	2: Str Ent	3: Lead & Pro Dev	In total
Full professor			1	1
Docent/asst. prof (associate professor)	1	3	4	8
Senior lecturer	3	2	4	9
Adjunct lecturer	5	3	9	17
PhD students		3	2	5
In total	9	11	20	40
Members with doctorates	4	5	9	18
Members with research leader competence	1	3	5	8

In terms of scientific mass, Group 3 is the strongest and Group 2 is second strongest. At present, there are 10 open positions that have been announced; there are now about 25 applicants for these positions. The expectation is that at least 8 new senior lecturers and associate professors with connections to Enterprises for the Future will be employed in next 12 months. It is also expected that each group will receive at least 2 senior researchers. A main hiring criterion is that the applicants have the ability and background such that they can contribute to the groups' research programmes.

The next table lists the disciplines of researchers in Enterprises for the Future.

	Number of staff	with doctorates
Marketing	7	3
Accounting/ management accounting	6	2
Organization and management	10	6
Business law	3	1
Statistics	3	0
Engineering	3	1
Economics	2	2
Logistics	4	2
Social psychology	2	1
SUM	40	18

It is a relative weakness of Enterprises for the Future that many lecturers do not have doctorates. One reason is that the University can only provide a limited amount of funding for doctoral candidates. This is a serious problem because sustainability of the research programme, in large part, depends upon its ability to attract external research grants in national and international competition. Most of these funds providers think doctoral education is more a university financial responsibility than their responsibility.

A3.3 Infrastructure, facilities and funding

Provide a description of the infrastructure of the UoA (not the general infrastructure of the university) that is used to do research (such as laboratories, specific ICT-support; infrastructure for fund raising, collaboration with society, etc.). (Max 3 pages)

We choose not to write anything specific here since there is not a great deal that we can describe as far as infrastructure and facilities in our field. Moreover, below we address about collaboration with society in some detail.

A4. Impact, engagement, and co-operation with society

In this section, the UoA describes its efforts to collaborate with society to ensure that research conducted has an impact on society. The section aims to provide the basis for a more holistic and situated evaluation of research impact than is possible from the cases (described in C).

A4.1. Collaboration with society in the UoA

Give an overview of the most promising current collaboration, including primary missions and goals. Describe how current collaboration affects the quality of research. Include evidence and specific details/examples adopted by the UoA rather than broad and vague statements. Do not repeat specific details already included in the case studies (section C). (Max 4 pages)

As an introduction, we briefly describe the region, its development and current situations. This introduction provides the context that explains how Enterprises for the Future interacts with (local) society.

The University of Skövde is located in the former county of Skaraborg, which merged in 1998 with other counties to form the Region West Sweden. The Skaraborg area, which is now the northeastern part of the Region, is relatively rural with an important agricultural sector in addition to many industrial firms (e.g., metals engineering and wood manufacturing). The service and governmental sectors in the area are relatively small. One exception is the Swedish Armed Forces, which has several army and air force regiments in the area.

Of the 1.6 million inhabitants in the Region West Sweden, about 250.000 live in the area of Skaraborg. Of the area's 15 municipalities, Skövde is the largest with around 50.000 inhabitants. Other relatively important municipalities in the area are Lidköping, Falköping, Mariestad and Skara, each with its own history and distinctive character. Before recent industrialization, Lidköping, Mariestad and Skara were the important municipalities for commerce, culture, and administrative functions. There has been some antagonism directed toward the municipality of Skövde because it is viewed as city without tradition and charm even though it has increasingly dominated the area in terms of commerce, employment opportunities and administrative functions. Nevertheless, despite this view of Skövde as a rather pretentious and arrogant municipality, a reason for area pride is that Skövde is the smallest municipality in Sweden with an independent university: The University of Skövde.

The University of Skövde is relatively small and relatively young by national comparisons. It was founded in 1977, and today has approximately 11000 students. The leading academic institutions in Region West Sweden are the University of Gothenburg and Chalmers University of Technology (both in Gothenburg). The University of Gothenburg is about ten times larger than the University of Skövde as far as number of faculty members. Moreover, the University of Gothenburg's fixed income for research is more than 30 times larger than that of the University of Skövde (1.3 billion SEK versus 40 million SEK). Two other universities in the region, The University of Borås and University West (in Trollhättan), are similar in size to the University of Skövde.

The national budget allocates the University of Skövde only 1.5% of the total grants for education and 0.3% of the direct university research funds. Thus, because of its relative small size compared to other Swedish universities, it is difficult for the University of Skövde to play a leading role in national and international settings, to participate in research consortia, to compete for excellence funds, and so on. With the exception of the discipline of Information Technology, the University of Skövde lacks the research reputation and funding to attract faculty from outside area. Thus, there is not only a problem with recruitment of faculty members but also with retention of faculty members. Despite these problems, the University of Skövde is attractive to some researchers who seek an organizational environment that is less traditional and entrenched than that typically found at older, more established universities.

Industrial clusters in Skaraborg

As part of the investigation assignment for the Enterprises for the Future, we identified particular industrial clusters in the Skaraborg area. The purpose of this assignment was to pinpoint those clusters with which we might collaborate in our research. Strong clusters have, for instance, resources that can be invested in cooperative projects and may attract other resources from external partners, research foundations, etc. We identified three industrial clusters in Skaraborg that are the strongest: 1) food and agriculture, 2) wood & furniture and 3) transportation (vehicle manufacturing). The Table below details comparative facts about the clusters in the Skaraborg area.

Industry/sector	No. of employees 2008 in Skaraborg	Relative quota*	Skaraborg's share of Region West Sweden

Food and agriculture	4393	2.57	39%
Wood & furniture	5108	2.27	35%
Transportation	6973	1.2	18%
Tourism & hospitality	3575	0.58	9%
Information Technology	1622	0.34	5%
Biomedicine and health care	227	0.21	3%
Marine sector	207	0.19	3%
Textiles	62	0.14	2%
Petroleum/plastics	54	0.05	1%

* A relative quota of 1.00 means that the employment in Skaraborg is at the regional average.

Ongoing collaborations

Despite the nascent state of the research centre, there are a number of ongoing collaborations with actors outside academia. Next we describe the most important collaborations.

Internationalization and Social Entrepreneurship: Important collaborators with the research group consist of other institutions such as the Industrial Development Corporation (IDC), ALMI and the Skaraborg Research Institute. These institutions are important actors in the research environment. They can assist in identifying and developing contacts with private firms and public organizations in the Skaraborg area. They also facilitate data collection, help arrange conferences, and provide classroom guest lecturers and conference keynote speakers. Such conferences, where we meet other researchers in the region, are useful for advancing our research projects.

Another important tentative collaboration is with the municipalities of Lidköping, Mariestad and Götene and local actors involved with the UNESCO Biosphere Reserve Area “Lake Vänern Archipelago and Mount Kinnekulle”. Biosphere Reserve Areas involve important institutions for developing and

disseminating knowledge about sustainable life forms. Lake Vänern is the largest lake in Europe outside Russia. The collaboration, which has generated a joint research application, is very much at the centre of our initiatives: the study of entrepreneurial action with a strong focus on sustainable and resilient behaviour. If there is a project, this will be the core of Social Entrepreneurship for Group 1.

Strategic Entrepreneurship: The group has several collaborations with national and international partners. At the regional level, they have an established network with several companies. Also, two group members have worked with IDC West for several years. IDC West is a union of 130 regional manufacturing companies. Our relationships with IDC give us access to these companies. As a result of the collaboration with IDC, one researcher in the group has conducted a study of 41 companies and more than 1000 respondents. Another researcher, who has worked for IDC for several years, has assisted IDC in applying for external grants. Also, the group has worked, or is currently working, with large companies, for example, NCC, Skanska and various SMEs located in other regions of Sweden (e.g., Borås, Alingsås, and Mälardalen).

The Strategic Entrepreneurship group has several collaborations with Swedish research institutions (e.g., universities in Jönköping, Umeå, Mälardalen, Örebro, and Gothenburg). Regarding international collaborations, a member of the group visits the University of Hong Kong two times a year as a visiting scholar; other researchers have collaborated with universities such as Charles Darwin University in Australia, Asian Institute of Technology in Thailand and Vietnam, Dokuz Eylül University in Turkey, and Tsinghua University and Nankai University in China. The group also works with numerous European universities, for example, Poznan University of Life Science in Poland, Vilnius University in Lithuania, Stockholm School of Economics in Riga, Latvia, and several German universities.

Leadership and Process Development: One of the most important collaborations for this group is with the retail sector (see Section C1 for more detail). Another major theme of the research group is the role of co-workers in relation to managers (medarbetarskap, approximately translated as “co-workership”). This theme and related ideas have influenced several organizations such as healthcare organizations, public authorities, the Swedish police, municipalities, manufacturing organizations, etc. Several research projects have been conducted with a focus on describing and developing co-workership. In collaboration with different parties, the concept and various

related models have been refined and communicated to other organizations in a book, lectures, and seminars. Important contacts with the municipality of Skövde have resulted in discussions about collaborative ways to increase the attractiveness of the municipality and to improve organizational and leadership practices in eldercare. We have also an ongoing project on alternative health insurance arrangements with the municipality. Established research contacts also exist with the regional hospital and Region West Sweden.

A5. Self-assessment and future development

In this section the UoA should provide a self-assessment of its present opportunities for improvements. What does the UoA aim to achieve, e.g. in terms of activities within the UoA, external networking, interdisciplinary activities, joint publications and funding?

A5.1 Self-assessment of the UoA

Based on the quantitative data (part B) and qualitative assessment above, list strengths, weaknesses, opportunities and challenges (threats) of the UoA and of the research conducted. Strengths and weaknesses refer to properties of the UoA, whereas opportunities and challenges normally refer to external factors. Propose actions that would improve the quality of the research. Consider both purely academic factors and factors related to cooperation with external partners.

The UoA must grade, on a scale 1-8, and motivate the premises and ability to

- *recruit qualified staff and PhD students,*
- *attract external research funding,*
- *position the UoA internationally.*

Here, 1 means poor and 8 means excellent. Apply a long-term perspective of the strategic planning of the UoA and what priorities that will be made regarding future research (max 10 pages).

In most instances, we applied the SWOT analysis and described the planning ideas mainly at the group level because each group has to conduct its own planning process. The reason is that the three groups, to a certain degree, operate in different scientific arenas and have different needs. Primarily, Groups 1 and 2 need to increase their research funding while Group 3 needs to

consolidate its financial base and increase its international dimension as far as collaborations and publications. The implication is not that the groups work independently from each other but rather that collaboration and knowledge exchange are difficult to manage at the central level. Therefore, it is more appropriate at the central level to facilitate and encourage cooperation than to coordinate it.

The important function of the centre is to set and implement five priorities that interconnect with each other. These priorities are described below, following the SWOT analysis.

Strengths

The novelty of the research initiative is, in part, an important strength. Because the centre is not heavily dependent on history and tradition, it has more flexibility in choosing its research interests and directions. The initiative's internal climate is also a strength in that there is a cooperative spirit across discipline borders. Thus, it is possible to form multi-disciplinary research teams that meet the requirements set by funding organizations and external partners. The well-developed collaborations with companies and other organizations that the research groups have formed are a third strength.

Weaknesses

An obvious weakness is the limited size of our research staff, especially the number of experienced and productive researchers. Additional staff recruitment is a significant concern. Second, it is difficult to publish multi-disciplinary research in many of the kinds of high quality journals we aim for. A third weakness is the relative low profile the University of Skövde has in the Swedish scientific community. As a result, the University of Skövde receives very little research funding from the Swedish government, especially compared to the funding provided the larger and more established universities in Stockholm, Gothenburg, Lund and Uppsala. This difficulty is exacerbated by the fact that, in their specializations, our research groups are not in the uppermost tier, on a national basis.

A fourth weakness is that the Skaraborg area is rather sparsely populated, with relatively few large and successful companies with the capacity and interest to invest time and money in research collaborations.

A fifth weakness is that the University of Skövde must cooperate with another university (e.g., the University of Gothenburg, Jönköping International Business School or Örebro University) in the recruitment and education of its doctoral

candidates. In a way, however, this situation is somewhat advantageous because our doctoral students can form research bridges to these other universities. Mutual work with doctoral students both facilitates collaboration and develops our cooperation skills.

Opportunities

The open research positions are an opportunity for the centre. When these positions are filled, we expect to strengthen our research competence in selected areas as well as complement our research skills. In particular, we think we have the opportunity to strengthen our quantitative research competence and skills.

We are convinced that the three research groups in Enterprises for the Future have the potential to be among the very best in Sweden in their research specializations within 3-5 years if we continue to work in a systematic way with the priorities we list (see below). We also think, given the practical relevancy of our research, we have the opportunity to enhance our profile in the mass media. Last, we view the possibilities to develop new research areas in new settings with our existing competences and skills as a very great opportunity.

Threats

The major threat is the possible failure to attract external grants. A second threat is the possibility of researcher turnover, particularly the departure of leading researchers. A third threat is the possibility of internal conflicts within or between the three groups.

Using the 1-8 grading scale, we grade Enterprises for the Future in three areas. In the Table below we present the grading at the group level and at the centre level (average).

We grade the first area (recruitment of qualified staff) as a **3** because such individuals are not readily available in the Skaraborg area. In addition, for some people, the residential area around the University of Skövde is less attractive than the areas near the leading Swedish universities. However, we note it is a reasonable commute between Skövde and Gothenburg, Jönköping and Örebro, cities with Universities with doctoral programs in our research specializations.

We grade the second area (external research funding) as a **4**. The groups differ in their ability to obtain grants with some more successful than others.

We grade the third area (international positioning) as a **5**. This grade is based on an average among the three groups.

	RG 1	RG 2	RG 3	EFF CENTRE* IN TOTAL
recruit qualified staff and PhD students,	2	3	4	3
attract external research funding,	2	4	6	4
position the UoA internationally.	5	4	5	5

*= Enterprises For the Future Centre

Goals and strategies for Enterprises for the Future

The research initiative Enterprises for the Future should be an integral part of the University of Skövde's development plans. The research areas and themes of the initiative relate to private sector businesses (especially small and medium size companies), non-profit organizations, and public sector entities.

Those of us involved in the establishment of Enterprises for the Future adhere to the University's vision of thematically coherent research that is of high international quality. Our goal is to dedicate our resources to strategic key areas by prioritizing those areas that contribute to the realization of this vision. Our five prioritized areas are the following:

- Competency enhancement through recruitment of researchers with current or potential international standing in the research community
- Development support so that each research group is recognized for its high level of internal cohesion and its inspired commitment to the research centre's vision, consistent with the University's goal of establishing itself as a leading international institution of higher education in selected areas
- Expansion of research funding applications. By 2015, the goal is least 12 million Swedish crowns annually from external funding sources.

- Establishment of collaborative efforts with researchers who have international recognition.
- Significant increase in the number of publications in international, peer-reviewed journal with high impact-factor.

Description and justification of the five priorities

Below we describe and justify the five priorities in greater detail with reference to the present situation.

Priority 1: Competency enhancement through recruitment of researchers with current or potential international standing in the research community.

At present: There are now about six to ten researchers at the centre who are either internationally recognized or have the potential to gain international recognition within the next five years. However, today, there are not enough researchers to establish Enterprises for the Future as an internationally prominent research facility. The long-term goal is that the centre should have about 20 scientists who are either internationally recognized or have the potential to become so.

Realization of Priority 1: The research centre's management recommends that all newly hired researchers should have the competence and skills to make a significant contribution toward the centre's vision. Moreover, doctoral students and lecturers should have the opportunity to become international leaders in their fields.

Priority 2: Development support so that each research group is recognized for its high level of internal cohesion and its inspired commitment to the research centre's vision, consistent with the University's goal of establishing itself as a leading international institution of higher education in selected areas.

At present: The research groups, to different degrees, have responsibility for most of the research activities such as individual skills development and the various research projects. The goal is that the research activities should be conducted within a research framework that involves several researchers who cooperate with each other. The research groups should compile a portfolio of 3 to 5 larger and more long-term research projects financed by various funding entities. One research project should be for at least five years. It is a concern that the University's vision and development plan has not yet inspired all researchers in Enterprises for the Future.

Realization of Priority 2: The research centre's management recommends that the teachers and researchers in Enterprises for the Future have more flexibility in their schedules so that they have the time to build a strong sense of unity within the groups. In addition, the groups need time to create and implement strategic business planning that includes prioritization of research projects and the establishment of a "task force" in each area that consists of approximately 4 to 6 researchers. The assignments for these "task forces" are to work on funding applications and to establish collaborative research partnerships with leading international research centres. Moreover, the "task forces" should organize meetings in which they inform all researchers of the goals and visions for both Enterprises for the Future and the University.

Priority 3: Expansion of research funding applications. By 2015, the goal is least 12 million Swedish crowns annually from external funding sources.

At present: Today the annual research funding from external sources is about 5 million Swedish crowns.

Realization of Priority 3: In addition making a much greater effort to conduct research in a number of attractive research problems in collaboration with actors from work life and with leading scientific authorities, each group should make a needs analysis. In addition, the groups should make plans on how to "cascade" the research applications such that the applications for more fundamental research are prioritized over applications for more applied (sub) projects. In addition, the planned Visiting Professor Programme for 2013-2014, in collaboration with the University of Borås, can lead to more research applications.

Priority 4: Establishment of collaborative efforts with researchers who have international recognition.

At present: There are now some international collaborations (e.g., with a research team at the Warwick Business School and a research team at the University of Lund led by Mats Alvesson). However, more international collaborations, both in numbers and in the level of research intensity, are needed.

Realization of Priority 4: After the research projects have been identified and prioritized, in connection with the funding applications, the research work can intensify. This activity should lead to contacts with collaboration partners who have similar strategic interests. At that point, regularly scheduled guest researcher exchanges should begin. It is expected that each researcher will spend, at minimum, two weeks annually on visits to the partners' universities.

Priority 5: Significant increase in the number of publications in international, peer-reviewed journal with high impact-factor.

At present: The bibliometric analysis reveals that members of Enterprises for the Future have published a relatively modest number of journal publications. There are several reasons, primary of which are inadequate staffing levels and insufficient funds. A senior lecturer in Business Administration and the like, without external funds, is expected to teach 1,400 hours annually as well as attend internal meetings, etc. (for 10% of their time). It is unrealistic to expect that a lecturer can conduct research that leads to publications in scientific journals in the remaining work time. Even when there was/ is external funding available, a researcher may be unable to use it owing to other institutional commitments. Moreover, many researchers have been educated to write monographs rather than articles. Journal articles of 5,000 to 8,000 words require a different kind of concentration and argumentative rigor.

Realization of Priority 5: All active researchers (in addition to other researchers within or outside the research centre) will be encouraged to write manuscripts for submission to high quality journals. An important aspect of the Visiting Professor Programme, in cooperation with the University of Borås, is an emphasis on academic writing. Prominent researchers will coach and provide feedback to the centre's members informally as well as formally in writing workshops.

Part B: Quantitative data of the UoA

In this part of the evaluation package questions and tables are presented in 3 sections which contain quantifiable information about the UoA in support of the statements made in Part A above.

B1: Research environment and infrastructure

B2: Research output

B3: Impact, engagement and co-operation with society

B1. Research environment and infrastructure

B1.1 Staff statistics

Provide information of the number of individuals and full time equivalents (FTE) of staffs' research activity. The 'M' columns show values for men and 'W' for women. The number of individuals refers to Dec 31st each year, whereas FTE is integrated over the whole year. FTE is only presented for 2011 and 2012.

Table B1.1.1. Number of and full time equivalents of permanent research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Professor					1		1		1		1	
FTE									0.5		0.4	
Assoc. prof. (Lektor and docent)					2		4		6		6	
FTE									1		1.7	
Assist. prof. (Lektor, forskare)	1	1	1		4	1	4	1	3	1	2	1
FTE									0.6	0.4	0.5	0.4
Lecturer (Adjunkt)						1		2	1		1	
FTE									0.1		0.1	
Total Individuals	1	1	1		7	2	9	3	11	1	10	1
Total FTE									2.2	0.4	2.7	0.4

¹ Professor denotes persons employed as full professors. Associate professor denotes staff qualified to act as principal advisor for PhD students (docent appointment or similar). Assistant professors denote the rest of staff with a PhD.

Table B1.1.2. Number of and full time equivalents of temporary research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Guest profs	1		1								1	
FTE											0.1	
Adjunct profs												
FTE												
Assistant professor												
FTE												
Post-Docs and research assistants	1				1		1					
FTE												
PhD students ¹							1		1		1	
FTE									0.8		0.8	
Total individuals	2		1		1		2		1		2	
Total FTE									0.8		0.9	

1 All temporary employed admitted to PhD studies

Table B1.1.3. Other staff supporting research in UoA												
Year	2007		2008		2009		2010		2011		2012	
Staff	M	W	M	W	M	W	M	W	M	W	M	W
Research assistant/ Technician										1		1
FTE										1		1
Administrator												
FTE												
Total individuals										1		1
Total FTE										1		1

¹ Fixed term and visiting research staff. Staff is included in the research output as well as in the bibliometric analysis.

The section B1.1 is commented in section A3.2

B1.2 Research funding

Sources of research funding and amounts given to the UoA annually during 2007-2012.

Table B.1.2.1. External funding (spent money in t SEK)						
	2007	2008	2009	2010	2011	2012
Research Councils (VR, FAS, Formas etc.)			450	662	1105	25
Swedish Foundations (e.g. Wallenberg, SSF, Vinnova, RJ, KK, Swedish Energy Agency etc.)		254	1294	1210	1317	1532
EU						
Other public bodies (e.g. county councils, municipalities, etc.)		184	704	256		
Direct external funding from industry.		22				656
University	317	326		11	286	15
Others (please specify), individuals					5	71
TOTAL	317	786	2448	2139	2713	2299

Table B.1.2.2. Total Research Funding t SEK						
	2007	2008	2009	2010	2011	2012
Total external funding (from table B.1.2.1.)	317	786	2448	2139	2713	2299
Faculty funding (governmental funding)	1652	1155	1875	3770	1912	2038
Percentage external funding	16	40	57	36	59	53
Research as competence development						
TOTAL						

The Tables in B1.2 were compiled by the University Accounting Department and show the amount spent on research each year (not the amount of the grants). Group 3, in particular, received several grants in 2011-2012 that have not been used quite as planned due to personnel shortage. These grants/projects are described in Group 3's document, Section A1.

B1.3 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during **2011-2012** by permanent research staff.

Table B1.3.1 International networks and collaborations	
Number of collaboration institutions ¹	
Number of research visits abroad (1 week to 1 month duration)	6
Number of research visits abroad (of at least 1 month duration)	
Number of visiting researchers (1 week to 1 month duration)	
Number of visiting researchers (of at least 1 month duration)	1
Number of funded international research consortia projects	

¹ Research collaborations given here are limited to those with joint research grants in excess of 100kSEK/year and/or joint publications with the UoA.

B1.3.2 Name of project granted and role of UoA			
Project title	Funding body	Role (coordinator/partner)	Start year

B1.3.3 Other major international activities according to the tradition of the research field¹	Total No.

¹ Please specify: scientific expeditions, field work etc. and list below including duration
A maximum of five examples in total may be provided.

B1.4. Participation in scientific community

UoAs activities undertaken during 2007-2012 that illustrate high quality leadership interactions with their scientific peers.

B1.4.1 Participation in academic community	Number
Plenary or keynote talk at international conferences	4
Assignment as expert in research councils and foundations	6
Assignment as expert evaluator for position as professor, associate professor (docent) and lecturer	11
Assignment as opponent for PhD thesis	5
Assignment as member of examination board for PhD thesis	11
Assignment as editor or member of editorial board for journal	4
Assignment as reviewer for international journal	88
Member of national scientific councils	

Member of international scientific councils	
Chair of program committee (international conferences)	
Member of program committee (international conferences)	3

B1.5 Recruitments

Number of recruited research staff, men (M) and women (W) during 2007-2012.

B1.5.1 Recruitments	Number	
	M	W
Recruitments with doctoral degree from another Swedish university	3	1
Recruitments with a doctoral degree from outside Sweden		
Recruitment with doctoral degree from own university		
TOTAL	3	1

B2. Research Output

B2.1 Promotions and degrees

This section quantifies the development of scientific staff during 2007 to 2012 distinguishing men (M) and women (W).

B2.1.1. Doctoral degrees awarded and promotion of researchers												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
No. Doctoral degrees	2		1	1							1	
No. Docent promotions					2				3			
No. Professor promotions					1							
TOTAL	2		1	1	3				3		1	

B2.2 Publications

Publications and other research output achieved during 2005-2012 to provide the publication profile of the UoA.

Table B2.2.1: Total number of scientific publications produced by the UoA. Please specify citation index in each publication list.

Publication types	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Article in journal, peer reviewed	3	1	8	6	8	11	5	6	48	6.0
Article in journal, not peer reviewed		1				1			2	0.3
Article in journal, book review								1	1	0.1
Article in journal, review				1					1	0.1
Book			15					1	16	2.0
Edited book					2	1	5	6	14	1.8
Chapter in book		3	4	3	9	4	9	14	46	5.8
Conference paper (peer reviewed)	1	4	12	8	7	5	17	6	60	7.5
Conference paper (not peer reviewed)	1	1	1						3	0.4
Thesis, doctoral	1								1	0.1
Thesis, licentiate ¹	1				1				2	0.3

Thesis, master	-	-	-	-	-	-	-	-	-	-
Report		1		1			1	1	4	0.5
Other scientific publication	-	-	-	-	-	-	-	-	-	-

¹ Licentiate is a Swedish and Finnish academic degree on graduate level corresponding to circa half a Swedish PhD.

Table B2.2.2. Aggregate publication information

	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Total number of publications in DiVA	7	11	40	19	27	22	37	35	198	24.8
Number of publications in Web of Science		1	2	3	3	4	4	2	19	2.4
Number of publications in Web of Science, author fractionalized		0.5	1.5	1.3	2.3	2.3	1.8	1.5	11.3	1.4
Web of Science visibility (percent of publications included)	0%	9%	5%	16%	11%	18%	11%	6%	10%	-
Scopus visibility (percent of publications included)	29%	9%	13%	32%	15%	27%	14%	14%	17%	-

Journals' field normalized impact		1.07	0.52	0.54	0.52	1.03	0.69	-	0.76	-
Journal Impact Factor			0.69	0.59	0.82	1.13	1.09	-	0.94	-
Norwegian score	2	1	12.7	9.4	12.2	9.4	11.8	17.9	76.4	9.6
Norwegian score fractiona-lized	0.8	0.5	9.5	5.5	7.5	6	8.8	12.4	51.0	6.4
Publica-tions in level 1 journal – Norwegian list	2	1	8	7	7	8	5	4	42	5.3
Publica-tions in level 2 journal – Norwegian list								1	1	0.1
Publica-tions in level 1 conference – Norwegian list			2	2	2		3		9	1.1
Publica-tions in level 2 conference – Norwegian list										0.0
Publica-tions in level 1 book publishers			1	1	5	2	4	7	20	2.5

Publications in level 2 book publishers			2				1	6	9	1.1
Table B2.2.3. Citation indicators										
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average	
Total number of citations		0	39	11	1	9	2	-	62	
Number of citations, author fractiona-lized		0.0	37.0	4.8	1.0	6.2	1.0	-	49.9	
Citations per publication		0.0	19.5	3.7	0.3	2.3	0.5	-	3.6	
Share of publica-tions not cited		100%	0%	0%	67%	0%	50%	-	29%	
Average field normalized citation rate		0	1.29	0.18	0	0.52	0.33	-	0.43	
Share of publica-tions among the 10 percent most cited in the field		0%	50%	0%	0%	0%	0%	-	7%	
Share of publica-tions among the 25 percent most cited in the field		0%	50%	0%	0%	0%	0%	-	7%	

Table B2.2.4. Authorship									
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Average authors per publication		2	1.5	2.7	1.7	2	2.3	1.5	2.0
Average countries per publication		2	1	1.3	1	1.3	1	1	1.2

Table B2.2.5. Role of key scholars									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Share of publications by 3 most active authors	29%	36%	28%	37%	48%	45%	54%	77%	47%

Table B2.2.6. Productivity								
	2007	2008	2009	2010	2011	2012	Total	Annual average
Number of publications in relation to total funding (MSEK).	17.40	7.70	6.10	3.44	7.17	8.07	7.18	8.31
Number of publications in relation to FTEs					10.88	8.75	9.73	9.82
Number of citations in relation to FTEs					0.59		0.59	0.59

The Tables above show an increase in research productivity. On average, in the years 2005-2010, 21 publications were produced annually, compared to 36 annually in the years 2011-2012. This is an increase of more than 70%. This expansion can be explained by the increase in research funding and by the recruitment of several very productive researchers. Additionally, we have emphasized the importance of research and publication activities in recent

years. In our opinion, the number of publications per full-time researcher is high.

The number of citations in the Tables is less encouraging. One reason is that many of the articles were published in journals not listed in the Science Citation Index/Social Science Citation Index. A second reason is that the increase in publications is not yet evident in the citation statistics. We expect the citations to increase by about 70% in the next few years owing to the increased number of our publication. A third reason is that several of our publications are books, book chapters and research reports.

We believe it is of interest for the evaluators to have a complete picture of the productivity by our leading researchers in the research initiative today, regardless of where their research was conducted. We also think such a picture, to have relevancy to the research initiative, should exclude publications by researchers no longer active at the University. The Table below shows the results of an internal search on Google Scholar conducted in June 2013. This Table lists the ten most-cited researchers in the initiative. In many cases, these researchers have public GS profiles.

Researchers	Research Group	Publications	Citations
Stefan Tengblad [^]	3 L & PD	113	519
Lennart Ljungberg	2 SE	7	220
Henrik Linderöth	2 SE	37	154
Desalegn Abraha*	1 I & SE	30	139
Thomas Andersson*	3 L & PD	38	81
Ali Kazemi	3 L & PD	24	79
Jim Andersen*	2 SE	13	79
Sandor Ujvari	3 L & PD	10	74
Max Zamanian	1 I & SE	4	41
Susanne Durst	1 I & SE	24	38
In total		300	1424

[^]= Centre leader

*= Research group leader

We note, with reference to the Table above, that the ten most productive researchers are distributed rather evenly among the groups, (between 3-4 per group). We also note that these Tables provide a much better view of the impact of the research initiative: there are more than 300 publications and more than 1400 citations for these ten researchers. These publications and citations include books (some in Swedish) and many sources other than journal articles. We expect that Google Scholar will register 200-300 citations in 2013.

Given the size of the research initiative and its funding, we think this is a respectable record.

B2.3 Innovation output

As well as engaging with society through contract research or education, researchers today sometimes patent their findings, commercializing these through multiple routes. Researchers also form companies either based on patents, or other forms of intellectual property e.g. materials, software or experience. These activities, often referred to as ‘innovation activities’, are listed in the tables below for the years 2007-2012.

B2.3.1. Patents ¹			
Patent number ²	Short description	Person(s) involved at UoA	Date of registration

¹ Data should match that held in DiVA.

² Awarded patents only, not patent applications.

B2.3.2. Founded companies ¹				
Company name	Founder(s) from the UoA	Company type	Date of formation	Current status

¹ Included eligible companies must be a direct result of the university’s research activities and have, or have had, an annual income in excess of 100 kSEK.

B3. Impact, engagement and co-operation in research with society

This section presents activities related to co-operation in research with society and the impact of such activities. It includes the unit’s general approach to enable impact and engagement from its research, and also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B3.1 PhD degrees

The number of doctoral degrees (PhD, etc.) earned within the UoA during 2007-2012 when the awardee has been externally employed. Number of men (‘M’) and number of women (‘W’) are recorded per year.

Table B3.1.1. Doctoral degrees awarded to students externally employed												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
Number of doctoral degrees												

B3.2 Major research related co-operation with society

Activities regarding research related co-operation with society should be entered into one of three categories in the table below: Table 3.2.1 lists mobility between academia and non-academic society, such as exchanged lectures with external (non-academic) organisations, the engagement of adjunct professors, and externally financed PhD students in collaborative research projects with partners from industry or other organisations in society; Table 3.2.2 includes the number of publications co-authored with individuals outside of academic institutions, and popular publications aiming at the general public; Table 3.2.3 counts the number of external partners of the UoA separated between SME, large enterprises, and non-industrial partners; Table 3.2.4 summarizes the amount of *in kind* funding from industry and non-industrial organisations in society.

Table 3.2.1: Mobility between academy and society						
	2007	2008	2009	2010	2011	2012
No. of collaborative doctoral students ¹						
No. of temporary research positions outside university ²						
No. of adjunct researchers						

¹Number of doctoral students in the UoA who are financed by non-academic external partners. Note that this does not mean doctoral students who are financed by any non-academic funding body, but students who are financed by external partners to the UoA (e.g. industry or public sector organisations).

²Permanent UoA personnel who migrate from the university to non-academic society

Table 3.2.2: Outreach activities						
	2007	2008	2009	2010	2011	2012
No. of scientific publications with representatives from society (not academia)						
No. of popular science publications (popular science magazines, including the internet)						

Table 3.2.3: Collaboration organizations (please provide description in A4.1.)						
	2007	2008	2009	2010	2011	2012
No. of partners from industry (SME) ¹						
No. of partners from industry (non SME)						
No. of partners from society excl. industry and academia						

¹enterprise with no more than 250 employee and an annual turnover not exceeding 50 M €.

Table 3.2.4: Indirect external funding (in t SEK)						
	2007	2008	2009	2010	2011	2012
Indirect funding from non-industrial organisations in society (in kind ¹)						
Indirect external funding from industry (in kind)						

¹value of working hours done by external partner, value of equipment, databases, software, laboratories etc. that external partners provide in joint research projects.

Part C: Case descriptions

C.1. Impact case

The number of cases required in each submission is two (max.). The case should have been carried out during the period January 1st 2007 to December 31st 2012. Each case must provide details not only of the academic impact e.g. publications in highly ranked journals, but also describe the impact of the excellent research on society.

Table C1.1.2 Template for impact cases (maximum 4 pages)
Title of case
Describe and provide evidence of the specific impact, including: <ul style="list-style-type: none"> - an explanation of the nature of the impact, - how far-reaching the impact is/who the beneficiaries are, - how significant the benefits are
Explain how the UoA research activity contributed or led to the impact, including: <ul style="list-style-type: none"> - an outline of what the underpinning research was, when this was undertaken and by whom, - what efforts were made by staff in the unit to exploit or apply the findings or secure the impact through its research expertise, - acknowledgement of any other significant factors or contributions to the impact
Provide references to: <ul style="list-style-type: none"> - key research outputs evidencing the impact (list of publications, patents etc.), - other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA
Any aspect the UoA wants to highlight

We have had a major impact on the retail sector in Sweden, especially retail management. Since 2005 we have had an educational programme for store managers. From the start, we saw the potential of this niche programme because about 1 of every 7 employees in Sweden works in the retail and wholesale sector. However, there were no academic programmes designed particularly for retail management at that time.

During its entire history, our retail educational programme has involved collaboration with municipal learning centres in about ten different municipalities in southern Sweden. Each municipal learning centre recruits stores as partners that the students visit and study during their education.

There is a large network of 5-8 learning centres (there have been different numbers of learning centres in different years), each with about 30-50 partner stores. Some years ago our researchers had established this network that allows us to link students and practicing retail managers and employees. However, we thought more could be done because our research on leadership inadequately addressed the retail sector.

Therefore, we initiated a retail research project hoping to attract external funding. In 2007 we applied for funding from Handels Utvecklingsråd (HUR) (English: The Swedish Retail and Wholesale Development Council), which is a foundation for employer associations (Arbetsgivarförbundet KFO and Svensk Handel) and national labour unions (Akademikerförbundet and Unionen). When we received a two-year funding grant, we began our research project in the summer of 2008.

A major aim of the project was that our research results should have practical use. A second aim was to have our students participate in a research project in which they created new knowledge about an industry many of them would probably work in after graduation. Consequently, we designed three different but interconnected surveys for store managers, store employees and customers. The students took these surveys to their partner stores. We repeated this procedure in a second year. Thus, two groups of students participated in the research project. They visited 113 stores and surveyed 113 store managers and 555 employees. In addition, 2308 customers responded to the survey.

The results from the surveys surprised us. We were impressed by the good work climate at the stores, by the highly motivated co-workers and by the cooperative relationships between managers and co-workers. The business media was interested in our findings. Several daily newspapers published our results, including Aftonbladet (the largest newspaper in Sweden with 2,9 million readers every day). Furthermore, our results received international attention because they differed significantly from international research results.

We even wrote a chapter for a research anthology called Retail Work in which we described and explained our results. Our main conclusion was that Swedish work life values – as opposed to the values of the international sector logic – influence the work and leadership in the Swedish retail sector. In addition, we have presented some aspects of our findings internationally at two conferences. One paper concerned good leadership and motivated co-workers. The other paper dealt with the effect on revenues of good leadership combined with co-worker responsibility sharing. The Swedish retail sector, in international comparisons, has done remarkably well, both regarding

productivity development and human resource management. These conference papers will be re-written for submission for journal publication in 2013/2014.

As a result of our discussions with HUR and of several research presentations for practitioners, it was apparent that a textbook focused on retail management, especially personnel work, was needed. We applied for further funds from HUR so that we could continue our international publication work including preparation of a textbook. When we received funding for the textbook, it became our main project in 2012. The textbook Uppdrag butikschef (English: Mission store manager) was published in March 2013. The textbook has received considerable interest from practicing store managers, store employee and students in our education programme for future store managers. This textbook will probably have a considerable effect on the practice of store managers in the future.

Our good collaboration with HUR, in particular, and with the retail sector, in general, continues. In 2013 we received a new research grant to study career development in retail. This two-year project will begin in October of 2013 and will run until September of 2015. Thus, our expectation is that we will continue to contribute to and influence the retail sector and that our mutually beneficial collaboration will continue.

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UNIVERSITY
OF SKÖVDE

Self-assessment

Health and Well-being: Individual
and Society

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ARC13 – Evaluation Package

Introduction

The following document describes the research and collaboration of defined units of assessment (UoA) at the University. The document includes indicators on research activities, research initiatives and collaboration in research in relation to academic, business, or public partners. The document also includes a qualitative self- assessment of the strengths, weaknesses; opportunities and threats (SWOT) of the UoA. The indicators aim to describe research activities in specific areas as well as in multi-disciplinary fields. Apart from direct research quality assessments, a number of different aspects are requested to be elucidated; description of the research field, research environment and infrastructure, research output, impact, engagement and co-operation with society (which in this document denotes organisations within business and public sector, non-governmental organisations, the public, but not including other academic institutions) and opportunities for renewal and actions for successful development. The document also includes two case descriptions identified by the UoA as particularly important or significant (see C). The document is structured in three parts:

Part A– Strategic information about the UoA (general description and SWOT-analysis)

Part B – Quantitative data describing the UoA (general information, research output and co-operation with society)

Part C – Case descriptions (two impact cases)

The parts are complementary. Information provided in either part should be used to support and deepen the information presented in the other.

ARC13 generally assesses the period January 2007 to the end of December 2012 (see appendix 1), although some of the indicators cover a shorter period of time. The expert panels are asked to assess the quality of research (and collaboration) at the UoA in an international perspective based on the instructions given in the *Terms of reference* (Appendix 1). In particular, the panels are asked to identify **strong research activities**, **strong collaboration with society** and **potentially interesting opportunities for development**.

Part A: Strategic information from the unit of assessment (UoA)

In this part of the evaluation package the UoA communicates information on organisation, co-operation and strategies chosen to ensure that relevant, high-quality research is conducted.

Table 0 – Name of the UoA	
Name of Unit of assessment	HEALTH AND WELL-BEING – INDIVIDUAL AND SOCIETY
Coordinator of Unit of assessment	Ingrid Bergh

A1. Description of the research in the UoA

This is an overview of the current research areas, including primary missions and goals, within the UoA. (Max 4 pages, in template format):

In Sweden, as in many Western countries, there is an increasing problem with illness associated with poor health and well-being related to physical, mental, emotional and social dimensions. This not only causes great suffering for the affected individuals but also negatively affects the health of the public sector and society as a whole. Therefore it is of great importance to identify practices and methods that promote health and well-being, in the short and long term at both an individual and societal level. Due to this situation, there is a need to develop multidisciplinary, evidence-based treatments and health and well-being promotion strategies. It is important to understand what underlying mechanisms, sense making practices, experiences, educational training, informal and formal learning throughout the life course, and support and care routines influence the promotion of health and well-being. Therefore we study outcomes of interdisciplinary mediations, which are built on a deep knowledge about people’s experiences, sense making and health processes across physical, mental, emotional and social dimensions. We need more knowledge about how people learn and take responsibility for their health situation—on an existential, social, communicative and relational level—in order to develop and implement new approaches and methods for supporting health and well-being. By gaining such knowledge we can further develop evidence-based and more efficient actions for health promotion. Further, such new knowledge would enable the introduction of new strategies to promote health and well-being in the private and public sector equally focused on the individual and societal levels.

During the past two years, intensive efforts have been made to create a coherent and consolidated research milieu with collaboration among researchers within as well as across different scientific areas (this is a process that is still on-going). This work has resulted in a health milieu based on research within the subjects of Nursing, Public Health and Reproductive, Perinatal, and Sexual Health (RPSH). These closely related subjects are strongly represented in the research milieu. A clear interdisciplinary profile is ensured, enabling researchers from the subjects of Social Psychology, Education and Music to also be involved in the research groups. Several of the researchers also have on-going and/or planned projects in collaboration with researchers in Biomedicine, Physiology and Computer Science within already established research centres at the University, which further ensures the interdisciplinary research profile within the University. The ambition is not only to produce knowledge applicable in the universities' courses, but also knowledge useful on an individual as well as societal level.

Well-being and health are closely related concepts and often used interchangeably. For example, the World Health Organisation (WHO) defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Overall health is thus achieved through a combination of physical, mental, emotional and social well-being. Physical health deals with the body's ability to function, and encompasses exercise, nutrition, sleep, alcohol and drugs, as well as weight management. Mental health deals with how we cope with daily life, stress management and mental illness. Social health deals with how we interact with people within our environment, including family relationships and peer relationships, and the public health domain.

Our health research milieu consists of four newly formed interrelated research groups with four specific research orientations: Well-being by Complementary and Alternative Methods (WellCam), Well-being by Learning (LearnWell), Well-being in Late Life (LateWell) and Well-being by Social Inclusion (SocInc). A joint research area is *Development of Instruments and Methods* (DIM). These research groups constitute the research milieu **Health and Well-being – Individual and Society** (HealWell) (Fig 1).

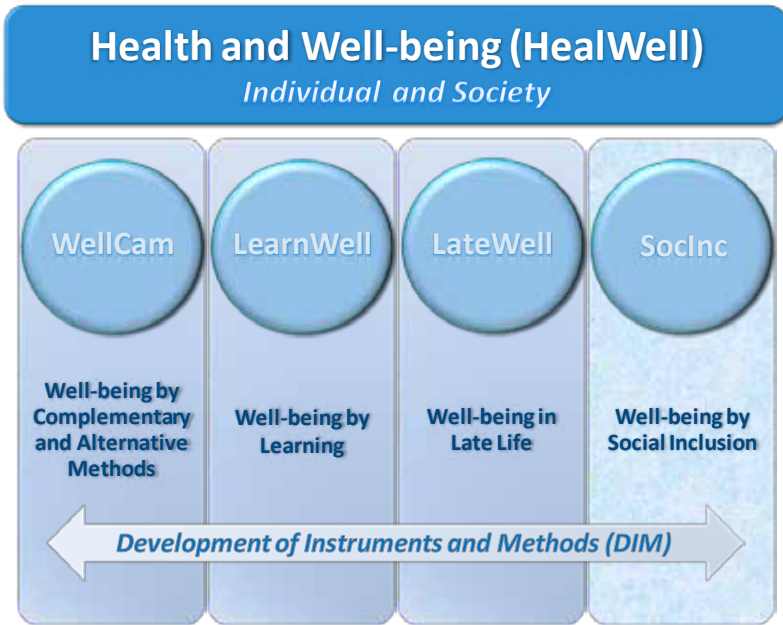


Figure 1. Overview of the research groups included in the research area Health and Well-being – Individual and Society, HEALWELL.

Well-being by Complementary and Alternative Methods (WellCam)

The interest in complementary and alternative methods is increasing in Sweden and the EU-region, as well as worldwide. For example more than one third of patients with long-lasting pain have used acupuncture in the EU and over 100 million people use complementary and alternative medicine. However, one problem using CAM in health care is the lack of studies of good quality evaluating the effectiveness and safety of these methods. The focus for this research orientation is therefore to evaluate and improve the evidence based on CAM used by people in the context of health promotion and health problems in both acute and chronic conditions. In addition we aim to explore the biological mechanisms of action in CAM relevant to the area in collaboration with researchers within the Systems Biology Research Centre. The research has mainly used randomised controlled trial (RCT) designs but qualitative approaches are also used.

This research group participates in several promising national (Karolinska Institute, Mälardalen University and Örebro University) and international (Australian Catholic University; University of Queensland, Australia; McMaster University, Canada) collaborations.

On-going projects within this research orientation include:

Mindfulness-based stress reduction in women with breast cancer (<http://clinicaltrials.gov/ct2/show/NCT01591915>); Acupuncture to reduce labour pain (<http://clinicaltrials.gov/ct2/show/NCT01197950>); Sterile water injections to reduce caesarean sections (<http://researchdata.and.s.org.au/do-sterile-water-injections-reduce-caesarean-sections-rct>); Can EMLA reduce injection pain associated with the injection of sterile water? (data collection start autumn 2013)—this is the first part in a larger study aimed at studying the effectiveness of sterile water injections in pain related to whiplash injuries; Effect of armchair with massage and relaxation program (<http://www.promas.se/miljoner-i-forskningsanslag-for-promasmetoden/>) (Effect of armchair with massage and relaxation program on recovery and health promotion—a randomised controlled study, financed by the Knowledge Foundation)
http://www.kks.se/verksamhet/_layouts/listform.aspx?PageType=4&ListId={BE0839F8-277C-4921-915A-03DACC37E526}&ID=1956&ContentTypeID=0x01008A041F6FAF91624D9A113964FD2B22BF); The effect of choir-singing on self-rated stress.

Well-being by Learning (LearnWell)

This research area is focused on developing knowledge about different aspects of support for learning processes in order to promote health and well-being throughout life. The research questions focus on how people in different situations (with health problems, illness and/or disease) make sense and learn to live with their health problems. The focus is also on how people learn to promote their health and well-being in everyday life and how students and health professionals learn to support health and well-being. The research mainly takes a qualitative approach but randomised controlled trials (RCT) are planned.

This research group participates in several promising national (University of Borås, Stockholm University of Jönköping, Linnaeus University, Karlstads University, Karolinska Institute, Örebro University, Stockholm University) and international (University of Eastern Finland, Network for Organisation Integrated Learning (VILÄR)) collaborations.

On-going projects within this research orientation include: Learning to manage illness and improve well-being and Carers learning to support patients learning. Didactic model “The challenge – to take charge of one’s life with long-term illness”; To support learning to live with long-term pain; Self-help groups for sustained weight reduction; A process-oriented breastfeeding training program for health professionals in order to develop positive attitudes

and to give support to parents during childbearing; Students' learning to support health and well-being; Students' learning in nursing education (DidAct); Learning to be a nurse - importance of frames and educational tools on students' learning; Lifelong learning in order to promote health and well-being; Academic professional education and professional practice on a scientific basis; Vocational education and vocational teachers for employment or skills for the future (Teaching for student motivation, ability and goals; Cooperation between school and workplace practice).

Teenage girls' well-being in school: A delicate 'balance between body and soul'? DISA as a preventive method in education; 'Bodying' digital interaction – well-being and meaning making. Teenage girls playing Wii; Runner's Digital Competence – Well-being through competition; Girls and boys – Selection and deselection in upper secondary school; Changing profession - From brush to academy; Lifelong learning in order to promote health and wellbeing – The impact of lifelong learning in people's experience of life choices; Digital democracy in the extended classroom: Digital media and the didactic design of the democratic conversation in secondary school teaching.

Well-being in Late Life (LateWell)

The number and proportion of older adults is increasing rapidly worldwide. In Sweden in 2012, there were approximately 1.8 million people who were aged 65 or older (19%). Therefore, to maintain and improve all aspects of quality of life and health for elderly citizens represents a real challenge for society and professionals. The research in this group is oriented towards health problems that often accompany late life, such as acute disease states, cancer, respiratory diseases, long-term musculoskeletal pain and dementia. Another orientation is the older adults' experience of home, health and well-being. This research encompasses the identification of care-related suffering experienced by older adults. The research conducted in this group also includes the existential dimension in life, which is important in supporting experiences of physical, mental, emotional and social well-being in different contexts, such as health care at end of life. The research uses both qualitative and quantitative approaches.

This research group participates in several promising national (Ersta Sköndal University College, Borås University, Jönköping University, and University of Gothenburg) and international (University of Johns Hopkins; University of Rhode Island, USA; The University of Adelaide, Australia) collaborations.

On-going projects within this research orientation include:

Older adults increased desire to remain at home and the changes in health policy with a transfer of advanced care from institutions into one's own home,

which raises the need to deepen the understanding of the experience of home among older adults in various contexts. This need is currently being addressed in collaboration with the University of Rhode Island, USA. Older adults' need of support in learning to live with long-term musculoskeletal pain will be addressed in an intervention study in collaboration with the University of Borås.

Home care on the patients or on the caregiver's terms; A description of home care interventions; Older adults' conceptions of home and experiences of living with long-term illness at home; Older adults' conceptions of home and experiences of living with long-term musculoskeletal pain at home; Oral health in palliative patients; Oral health in older people; Older patients who are conscious during mechanical ventilator treatment; Detection and assessment of pain in people with dementia in Swedish municipal caring practice.

Well-being by Social Inclusion (SocInc)

Within "HealWell" there is an ambition to support the development of a research group within the area Well-being by Social Inclusion. Social exclusion refers to processes in which individuals or entire communities of people are systematically blocked from rights, opportunities and resources (e.g. housing, education, employment, healthcare, civic engagement, democratic participation) that are normally available to members of society and which are key to social integration. The term social *inclusion* denotes a salutogenic perspective. Disciplines in which social exclusion is traditionally studied include: public health, sociology and psychology, politics and economics and community collaboration. The resulting alienation or disenfranchisement is often connected to a person's social class, educational status, and living standards. Frequently mentioned groups include: people with a disability, minorities, people of all sexual orientations and gender identities, young adults and elderly people.

The outcome of social exclusion is that affected individuals or communities are prevented from participating fully in the economic, social, and political life of the society in which they live. Material deprivation is a common result. Poverty, emotional and psychological trauma, and its resulting diseases may result in catastrophic damage to lives, health, and psyche. The research uses both qualitative and quantitative approaches.

This research orientation participates in several promising national (Karolinska Institute, Örebro University) and international (Catholic University of Milan, Italy; University of Stirling, UK) collaborations.

On-going project in this research orientation include: Psychological ill-being among young adults, which is a collaborative project with researchers in Social

Psychology and Public Health from the University of Skövde together with Skövde Municipality. This aims to study young adults in the age range of 18 to 25 in Skövde who are excluded from society. These young adults are neither part of the education or labour market. Via semi-structured narrative interviews 10 young adults are interviewed about their life style, conceptions of the adult life and its challenges, and their needs and expectations from society. The project is a pilot study and is intended to lay the groundwork for designing an intervention study aiming to promote well-being and functioning of this age group in society (data collection completed).

Girls and boys – selection and deselection in upper secondary school: Swedish upper secondary school in recent years has undergone major changes. Political decisions have intended to improve students' knowledge development, employability, and preparation for further studies. In parallel with these changes the choices of education are strongly gendered, with consequences for students who choose untraditional programs. The rate of dropout and program change is high. In this study, we intend to follow girls' and boys' life situation from a school perspective. This means that the study focuses on boys' and girls' selection and deselection, opportunities and obstacles, identities and social conditions in the institution school.

The aim of assessing the well-being of teenagers is to get a deeper understanding of teenagers' attitudes and behaviour towards sexuality, pregnancy and parenthood. On the issue of teenagers' sexuality, major contributions are in the areas of preventing teenage pregnancy and promoting teenagers' sexual and reproductive health.

Development of Instruments and Methods (DIM)

Development of instruments and methods is a joint research area within **Health and Well-being—from Individual to Society**. In order to measure outcomes of interventions and implementations, one main research area is developing and validating instruments and refining their applications. Another research area is refining existing methods and developing new approaches in qualitative research. More specifically, this research area focuses on improving research methods and instruments for studying human experiences and conceptions of, for example, various types of symptoms, attitudes, learning, support and interaction.

On-going projects within this research orientation: Testing reliability and validity of the Acceptance Symptom Assessment Scale (ASAS) among patients in palliative care, patients with malign and non-malign long-term pain; Evaluation of the Mother/Father-to-Infant relation and feeling scale; Assessment of health care professionals attitudes of dying patients; Evaluation

of the usefulness of the Abbey pain scale in patients with moderate and severe dementia.

A2. Summary of the scientific results

This qualitative summary of the most important scientific results of the UoA should reflect the width of the research and make reference to no more than 30 publications (Table A2.1) and other research outputs (Table A2.2). The summary should include comments to the publication and citation profile as presented in section B2.2, including the coverage of output from staff no longer affiliated to the UoA.

During the past two years the main focus of "HealWell" has been to create a coherent and consolidated research milieu, and to increase collaboration among researchers within as well as across different scientific areas, and also within society (e.g. health care). The objective is to establish a strong cohesive academic environment, consisting of four orientations, with the ability to contribute their knowledge to each other.

Well-being by Complementary and Alternative Methods (WELLCAM)

Sterile water injections (SWI) for pain relief are a simple technique; small amounts of sterile water are injected at the site in which the pain is located. Pain relief most often occurs within minutes and SWI can be repeated as needed. Research by Mårtensson has proven its effectiveness to relieve back pain during childbirth [1]. Mårtensson's research has also contributed with knowledge, resulting in a RCT study (in which she is co-investigator) investigating the impact on caesarean sections rates [2]. Additionally, she has conducted several surveys [3, 4] regarding the use of SWI in midwifery. This research has resulted in an increased use of SWI in Swedish midwifery. The Royal Dutch Organisation of Midwives have for several years been in contact with Mårtensson to learn about the method and also acquire evidence-based knowledge in order to get the Dutch Ministry of Public Health to give Dutch midwives permission to use the method during childbirth. This research has also resulted in several larger national applications for grants in co-operation with research within the orientation as well national and international researchers.

Acupuncture is commonly used in midwifery for pain relief. Mårtensson has compared the pain relief effectiveness of SWI and acupuncture in an RCT study that concluded that SWI was superior for relief of back pain in labour compared to acupuncture, which had a limited effect [1]. Mårtensson has also conducted several national surveys [5, 6] regarding the use of acupuncture in midwifery. Mårtensson's research has resulted in a decreased use of

acupuncture in Swedish midwifery. This research has also resulted in several international collaborations that have applied for funding to expand research on SWI to include patients with long-term pain.

Well-being by Learning (LEARNWELL)

Support and attitudes during the childbearing period—Focuses on observations and interview studies of parents' and midwives' experience of professional and social support in connection with childbirth [7, 8]. Another focus is to investigate economic factors and women's perceptions towards their childbirth experience and right to choose the place of birth [9]. The research also deals with factors influencing breastfeeding duration and mothers' and health professionals' experiences of breastfeeding support, as well as utilisation of health and delivery care [10, 11]. The relevance of this research is to increase knowledge about parents' and midwives' experience of professional and social support in connection with childbearing and breastfeeding, and women's perceptions towards their childbirth and right to choose the place of birth in order to give good professional support to parents during childbearing. Major contributions are to investigate the parents' and midwives' experience of professional and social support in connection with childbirth, the women's perceptions towards their childbirth, right to choose place of birth, mothers' and health professionals' experiences of breastfeeding support, and identification of factors influencing breastfeeding duration. Another perspective includes how parents of preterm babies perceive the experience as parents during their stay at the neonatal intensive care, where the parents act as caregivers while holding their baby skin-to-skin [12]. Clinical relevance of the project: holding preterm babies' skin-to-skin with their parents strengthens changes in routines at neo-natal wards, aiming to optimize the well-being of babies and their parents. Another project of clinical relevance is to increase knowledge about the utilisation of health and delivery care and postnatal vitamin supplements with the baby.

Process-oriented education for health professionals in support during childbearing and breastfeeding — Major applied contributions are in the understanding of how a process-oriented education in support during childbearing and breastfeeding for antenatal midwives and postnatal nurses changed the health care professionals' attitudes in a positive way; strengthened the mothers' perception of support from the professionals; and improved the maternal relationship and feelings for the baby. There was also a positive correlation between preparation for the parental role and a reduced number of infants being given breast-milk substitutes without medical reasons during the first week, as well as a delayed introduction of breast-milk substitutes after discharge from the hospital, if the health professional

received the process-oriented education. Furthermore, increasing the knowledge of a process-oriented education can reinforce the educational impact on the midwifery students' learning and development of professional skills in their education [7, 10, 11].

Research within this orientation has also had an international perspective, and dealt with how socio-economic factors affect breast-feeding and use of delivery care. One of the researchers (Elisabeth Kylberg) has also been involved in the development and adaption of the Baby Friendly Hospital Initiative (WHO/UNICEF) in neonatal care [12].

Susanne Gustavsson has carried out research [13] on 'impact in society'. The practice-oriented research of Gustavssons provides concrete findings for the communal educational practice community. Her results prove to have a direct applicability and usefulness in current societal/educational practice in and through which results are derived. The applicability and applied research provides societal effects that contribute to, and at the same time are an active part of, change and development that benefits the school teachers' professional skills as concerns health and wellness-related issues through an emphasis on reflexive practices.

Maia Olson's research has been brought up at the (educational) policy level as part of an on-going review of policies to improve and also effectively evaluate the school's statutory democratic socialization assignment. The results from her research [14, 15], which are mentioned in a report from the National Agency for Education (2010), involve concrete suggestions about how to come to terms with the schools' commissioned assignment to provide for citizen competence among young people in comprehensive schools. Maria Olson, together with some research colleagues, has also had an impact in the Nordic Council of Ministers.

The results from Mia Berglund's research [16, 17] have been given attention in the nursing area. The thesis results show how people learn to live with long-term illness. The thesis included a didactic model "The challenge – to take charge of one's life with long-term illness" that has had an impact on the learning of the carers in giving support to their patients on an existential level. The implementation process of the didactic model is being studied as a piloted project at Jönköping Ryhov Hospital. The model is also a theoretical basis for a study in the co-operation project with Borås University (To support old people in the pain learning process).

Well-being in Late Life (LATEWELL)

Catharina Gillsjö has carried out two studies [18, 19] of older adults' experiences of home. Home is central in life for many older adults and

increasingly important in the delivery of services in the health care sector. However, home remains theoretically and empirically underdeveloped in nursing. A concept analysis of home was made and home was defined as a place to which one is attached, feels comfortable and secure and has the experience of dwelling. Home was experienced as an intimate place, integral to life itself and the older adult's sense of being but also accompanied with tension and fear over the inevitability of losing the sense of being at home. A potential threat to losing home is musculoskeletal pain which is a major, but unfortunately often unrecognized, health problem among older adults. The experience of this type of pain was dominated by a feeling of being forced into learning, on one's own, how to endure and live with pain in daily life [20].

Older adults increased the desire to remain at home and the changes in health policy with a transfer of advanced care from institutions into one's own home raises the need to deepen the understanding of the experience of home among older adults in various contexts. This need will be addressed in collaboration with the University of Rhode Island, USA. Older adults' need of support in learning to live with long-term musculoskeletal pain will be addressed in an intervention study in collaboration with the University of Borås.

Well-being by Social Inclusion (SocInc)

Well-being for teenagers — Teenage sexual and reproductive health includes research on teenage pregnancy and motherhood, values to sexual risk-taking and living with genital warts care [21]. It is important to increase knowledge about teenagers' attitudes and behaviour towards sexuality, pregnancy and parenthood in order to give better professional support and empower the teenagers' own choices and responsibility. A major contribution of the study is to get a deeper understanding of teenagers' attitudes and behaviour towards sexuality, pregnancy and parenthood. On the issue of teenagers' sexuality, major contributions are in preventing teenage pregnancy and promoting teenagers' sexual and reproductive health, as well as acceptance and clear communication. In the discussions with teenagers about sexual risk-taking, the discussion must have reference to the young person's own reality [21]. The concept of justice is central to the understanding of well-being and social inclusion and exclusion. Distribution of goods and life conditions (i.e. social justice) affects the well-being of individuals and exclusion is defined as "when individuals or groups are perceived as outside the boundary in which moral values, rules, and considerations of fairness apply". Ali Kazemi and Kjell Törnblom's research in the field of social justice is internationally acknowledged [22]. Ali Kazemi has also published work in the field of well-being. His research has dealt with the conceptualisation and measurement of social well-being. This research within this orientation dealing with the

conceptualisation of "well-being" [22, 23] and public health issues [24] has resulted in an invitation to the author, in collaboration with Elisabeth Kylberg and Diana Stark Ekman, to contribute several chapters to the interdisciplinary work the "Encyclopedia of Human Services and Diversity" (Elsevier), which is a part of the "International Encyclopedia of the Social and Behavioural Sciences". The chapters are "Differing Attitudes Toward Health and Sickness", Lead Author: Ali Kazemi; "Home and Community Services", Lead Author: Diana Stark Ekman and "Nutritional Services and Assessment", Lead Author: Elisabeth Kylberg.

Development of Instruments and Methods (DIM)

The reliability and validity of the Acceptance Symptom Assessment Scale (ASAS) has been validated among women in childbirth [25]. Since there is a lack of valid pain rating tools in midwifery, this research has resulted in this pain scale being recognized by clinicians in Turkey as well as in Portugal.

Exploring the pain ratings in various populations, this research explores the complexity of a commonly used pain rating scale [25, 26].

Evaluation of the Mother/Father-to-Infant relation and feeling scale—Mothers' and fathers' perception of their relationship with their baby might affect sensitive parenting. This study [27] aims to explore mothers' and fathers' feelings for, and their relation to, the baby associated with how they responded to the "mother/father to infant relation and feelings (MIRF) scale" as a step in the validation process of the scale. Both qualitative and quantitative methods are used in these validation studies.

In the assessment of attitudes of dying patients, this area deals with the translation of psychometric testing of the Frommelt Attitudes Toward Care of the Dying (FATCOD), in order to assess the attitudes of dying patients [28]. This research contributes to the possibility to assess educational intervention in order to prepare nursing students to meet and care for dying patients.

Validity and Reliability of the Swedish Version of the Memorial Symptom Assessment Scale (MSAS) [29]

Translation and evaluation of the Child Drawing: Hospital Manual [30] has provided an instrument to evaluate children's anxiety by drawings. The instrument is now used in a longitudinal multi-centre study (Stockholm, Uppsala, Umeå) involving children diagnosed with cancer

There have been intensive efforts to create a coherent and consolidated research milieu with collaboration among researchers within as well as across different scientific areas. This work has so far resulted in an increased co-

production and co-authorship within as well as across different scientific areas, especially in Nursing, RPSH and Public Health.

Table A2.1. Selected peer-reviewed publications¹

1. **Mårtensson, L.**, E. Stener-Victorin, and G. Wallin, *Acupuncture versus subcutaneous injections of sterile water as treatment for labour pain*. Acta Obstet Gynecol Scand, 2008. **87**(2): p. 171-7.
http://his.worldcat.org/title/acupuncture-versus-subcutaneous-injections-of-sterile-water-as-treatment-for-labour-pain/oclc/361706581&referer=brief_results
2. Lee, N., **L.B. Mårtensson**, C. Homer, J. Webster, K. Gibbons, H. Stapleton, N.D. Santos, M. Beckmann, Y. Gao, and S. Kildea, *Impact on Caesarean section rates following injections of sterile water (ICARIS): a multicentre randomised controlled trial*. BMC Pregnancy Childbirth, 2013. **13**: p. 105.
<https://libraryproxy.his.se/login?url=http://link.springer.com/article/10.1186%2F1471-2393-13-105>
3. **Mårtensson, L.**, M. McSwiggin, and J.S. Mercer, *US midwives' knowledge and use of sterile water injections for labor pain*. Journal of midwifery & women's health, 2008. **53**(2): p. 115-22.
http://his.worldcat.org/title/us-midwives-knowledge-and-use-of-sterile-water-injections-for-labor-pain/oclc/464567772&referer=brief_results
4. Lee, N., **L. Mårtensson**, and S. Kileda, *Cross sectional study of Australian midwives knowledge and use of sterile water injections for pain relief in labour*. Women and Birth, 2012. **25**(4): p. e75-e80.
http://his.worldcat.org/title/cross-sectional-study-of-australian-midwives-knowledge-and-use-of-sterile-water-injections-for-pain-relief-in-labour/oclc/819455978&referer=brief_results
5. Schytt, E., A. Halvarsson, C. Pedersen-Draper, and **L. Mårtensson**, *Incompleteness of Swedish local clinical guidelines for acupuncture treatment during childbirth*. Acta Obstet Gynecol Scand, 2011. **90**(1): p. 77-82.
http://his.worldcat.org/title/incompleteness-of-swedish-local-clinical-guidelines-for-acupuncture-treatment-during-childbirth/oclc/704730110&referer=brief_results
6. **Mårtensson, L.**, L.J. Kvist, and E. Hermansson, *A national survey of how acupuncture is currently used in midwifery care at Swedish maternity units*. Midwifery, 2010. **27**(1): p. 87-92.
http://his.worldcat.org/title/a-national-survey-of-how-acupuncture-is-currently-used-in-midwifery-care-at-swedish-maternity-units/oclc/4652142875&referer=brief_results
7. **Thorstensson, S.**, E. Nissen, and A. Ekström, *Professional Support in Pregnancy Influence Maternal Relation to and Feelings for the Baby after Cesarean Birth : An Intervention Study*. Journal of Nursing and Care, 2012. **1**(4): p. 112-.
<http://www.omicsgroup.org/journals/2167-1168/2167-1168-1-112.digital/2167-1168-1-112.html> [Open access]
8. **Thorstensson, S.**, A. Ekström, I. Lundgren, and E. Hertfelt Wahn, *Exploring Professional Support Offered by Midwives during Labour : An Observation and Interview Study*. Nursing Research and Practice, 2012. **2012**: p. Article ID

- 648405-
<http://www.hindawi.com/journals/nrp/2012/648405/> [Open access]
9. **Dalal, K., J. Shabnam, J. Andrews-Chavez, L.B. Martensson, and T. Timpka,** *Economic empowerment of women and utilization of maternal delivery care in Bangladesh.* International journal of preventive medicine, 2012. **3**(9): p. 628-36.
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¹Publications should be listed in Harvard format. DOI=The Digital Object identifier system, for scientific publications is added in the following format: DOI: 10.1016/j. tibtech.2007.05.002 As a service for the expert panel, the listed publications are available to the expert panel as pdfs. Where the publication takes the form of a book, two copies should be provided.

Table A2.2. Other major research outputs¹			
Type of output	Main person responsible	Description	Date when became publicly available
Research-based clinical case studies	Lena Mårtensson	Evaluation of sterile water injections	2010 [31] (see table A2.1 for full reference)
Systematic review	Lena Mårtensson	Sterile water injections as treatment for low-back pain during labour	2008 [32] (see table A2.1 for full reference)

¹There is a maximum number of research output submissions allowed. The number of key research outputs, whether publication or other research output, is limited to the total number of professors within a UoA multiplied by four. The number should be four in case the UoA does not have a professor. Internationally acknowledged research outputs such as new materials, products and processes, patents, software, computer code, standards documents, evidence synthesis including systematic reviews, analyses, meta-analyses, research-based clinical case studies that add new knowledge, physical artefacts such as images, materials products and processes, prototypes, digital artefacts such as datasets, software, film and other non-print media etc.

A3. Research environment and infrastructure

In this section, the UoA presents the research environment that constitutes the context and breeding ground of its research.

A3.1 Organisation of the UoA

A description of how the UoA is organised; how research is managed and quality-secured; a presentation of research groups; how efforts of fund-raising are structured. (Max 2 pages for UoA and an additional ½ page per group)

During the past two years, intensive efforts have been made to create a coherent research orientation and collaboration among researchers within as well as across different scientific areas. This work has resulted in a health milieu based on research within the subjects Nursing, Public Health and Reproductive, Perinatal and Sexual Health (RPSH). These three closely related subjects are strongly represented in the research milieu. A clear interdisciplinary profile is ensured, enabling researchers from the subject Social Psychology, Education (Pedagogy), and Music to also be involved in the research groups. Several of the researchers also have on-going and/or planned projects in collaboration with researchers in biomedicine and physiology and within already established research centres at the University, which further

ensures the interdisciplinary research profile within the University. The ambition is not only to produce knowledge applicable in the universities' courses, but also knowledge useful on an individual as well as society level.

During the autumn 2012, the researchers within the research milieu were invited to participate in two separate workshops. The purpose of these meetings was to organize the prerequisites, demarcation and structure of a research milieu within the area "Health and Well-being". These meetings resulted in the formation of the research milieu as it is presented in Figure 1.

Weekly lunch research seminars have been arranged on a regular basis, attended mostly by researchers and PhD students in Nursing and Public Health. However, a reorganization of the University's institutions will facilitate researchers and PhD students representing the subjects included attending these lunches, as the research environment will then be part of the same institution. The purpose of these seminars is to create an "academic discussion" addressing everything from a review of research proposals and manuscripts to information and discussions of various issues of interest to the milieu.

"HealWell" also has a steering committee that constitutes one chairman and the leaders from each research orientation. External representatives from health care organizations, education and social services are also included. The steering committee is today responsible for the preparation of the application to establish a research centre within the area Health and Well-being-Individual and Society (HealWell) at the University of Skövde.

Each research orientation has a leader who currently serves as the convener in the orientation. This person is also responsible for the academic milieu within the orientation, represents the orientation in public and official meetings and belongs to the steering committee. Within each research orientation there are also project groups.

The steering committee has had four meetings per year. The research orientations have monthly meetings. The project group has meetings as needed.

Fund-raising is mainly managed within the project groups; however, as the formation of the research milieu is progressing, this is planned to also be managed by the research orientations and the steering committee in collaboration with the project groups in order to provide support in this process.

A3.2 Personnel

Present a general analysis on staff related to personnel tables in section B1.1 (Max 1 page)

Due to the intensive efforts to create a coherent and consolidated research milieu during the past two years, several researchers have moved to other research milieus within the University or other universities. However, several researchers have also applied for employment at the University because of the work with the research milieu "HealWell".

The research milieu has a large proportion of PhDs, but few senior researchers or PhD students. There is also an uneven distribution of competences among the research orientations. However, we work actively and systematically as PhDs and associate professors to qualify for promotion. This work has so far resulted 1 of the associate professors being promoted to full professor June 1, 2013. Three of the PhDs are expected to apply for promotion to associate professor during 2013. In addition, two associate professors are expected to apply for promotion to full professor during 2014 or 2015. Three PhD students are expected to defend their thesis during 2014. One new PhD student is included in the research milieu in autumn 2013, which is financed by Skaraborg Hospital. Furthermore, discussions were held with Skaraborg Hospital to finance one more PhD student.

PhD students within "HealWell" are registered at either the University of Örebro or Jönköping University, with whom we have an agreement. In addition, during spring 2013 a process started to recruit senior researchers in Nursing and Public Health to strengthen the competences in the research groups. Moreover, there is an on-going process to identify and support PhD's and associate professors to advance to associate professor and professor, respectively.

The university particularly encourages collaboration with the University of Borås. Accordingly, two of the research orientations (LearnWell and LateWell) have started a collaboration within the research program "Aging, living and learning" at the University of Borås. This will facilitate a collaborative milieu with a high competence within the research area "aging" as well as "learning". There is also a potential to include the orientation "SocInc" in this collaboration.

A3.3 Infrastructure, facilities and funding

Provide a description of the infrastructure of the UoA (not the general infrastructure of the university) that is used to do research (such as laboratories, specific ICT-support; infrastructure for fund raising, collaboration with society, etc.). (Max 3 pages)

The research milieu and its researchers are mainly located at G-building at the University of Skövde, distributed across all three floors. Researchers within the subject Education are located in the E-building. This dispersion impedes the academic dynamics both on a daily basis and from a long-term perspective. In the impending reorganization of the University's institutions, it is important to consider the relocation of staff to ensure that a closer contact between researchers in the "HealWell" milieu will be significantly improved.

Our adjunct researcher can apply for grants through the Local (Skaraborg) as well as Regional (Västra Götaland) Research and Development Units.

"HealWell" has one project funded by the KK-foundation "Effect of the armchair with massage and relaxation program on recovery and health promotion—a randomized controlled study"

(<http://www.promas.se/miljoner-i-forskningsanslag-for-promasmetoden/>). To

be able to apply for grants for funding at the KK-foundation, the research project must be co-produced with business and contribute towards advancement and renewal by the research groups and participating companies. No tax-paid business or company can be considered as a collaboration partner. UoA has the intention to focus on developing new theories and methods to increase the understanding of wellbeing. The project supports this process through the development of theoretical models for the study of causality and relationship of underlying factors. Furthermore, the project offers a demonstrator of how to study the interaction between underlying physical, mental, and social well-being mechanisms. The participating research group from UoA is unique in its combination of competences since it includes excellent competence within the fields of RPSH, public health and nursing (Anette Ekström), psychology, neurobiology, physiology, endocrinology, medicine (Kerstin Uvnäs Moberg & Linda Handlin) and mathematics and statistics (Mikael Harlén).

A4. Impact, engagement, and co-operation with society

In this section, the UoA describes its efforts to collaborate with society to ensure that research conducted has an impact on society. The section aims to provide the basis for a more holistic and situated evaluation of research impact than is possible from the cases (described in C).

From 2012, new agreements for cooperation in public health between the 15 municipalities in Skaraborg and two Health Boards in Skaraborg have been introduced. The agreements emphasise that public health is a strategically important issue. The agreements also highlight the strategic plan of the two Health Boards, best health by 2020.

To coordinate and develop this joint work, a strategy group of officials has been appointed. In this group of officials, one of the researchers is “SocInc”, which has been appointed as a member. This appointment facilitates the possibility to identify research areas that meet societal needs.

The research milieu has initiated collaboration with the public sector (health care and social services) in the surrounding communities; so far this has resulted in one co-financed PhD student and one research project funded by Skövde municipality. The main purpose of this collaboration is to provide the public sector with evidence-based knowledge. The main focus is on the public sector as the provider of the research question. Another important issue related to the public sector is the ambition that all students’ theses that fall within the subject represented in the milieu should be written within the research orientations, and with content relevant for the public sector. A conference (spring 2014) focusing on how scientific knowledge is implemented in the public sector (health care education and social services) is planned in collaboration with the Skaraborg Institute for Research and Development, representatives for the health care sector and social services.

Two of the researchers are adjuncts from the Skaraborg Hospital to the University 20% (of the time) and one of the researchers is adjunct from the University to Skaraborg hospital also at 20%. One PhD working full time at Skaraborg Hospital is also working in close collaboration with the research milieu. These researchers also act as a bridge between the university to help meet the clinic's needs for research and feedback of results. We also have an on-going process to further adjunct research in the public sector with relevant competence and a research focus on "HealWell".

A4.1. Collaboration with society in the UoA

Give an overview of the most promising current collaborations, including primary missions and goals. Describe how current collaboration affects the quality of research. Include evidence and specific details/examples adopted by the UoA rather than broad and vague statements. Do not repeat specific details already included in the case studies (section C). (Max 4 pages)

The Skövde municipality has financed 1 PhD student within the research orientation “LateWell” for 40% full-time (university 60%). The intention with this initiative is that the municipality wants to improve evidence-based

research on pain management in dementia care. Skaraborg Hospital has also agreed to fully fund 1 PhD student from the autumn of 2013 until dissertation. Furthermore, discussions have been held with Skaraborg Hospital to finance one more PhD student.

”SocInc” has a well-developed collaboration with Skövde municipality, which has resulted in the funding of a pilot study investigating young adults that are part of neither education nor labour market.

A4.2 External collaborations and contributions that support the research within the UoA

Describe supporting key external research collaborations and contributions from actors outside the UoA. Describe facilities and advanced equipment at partner organizations that is used by the UoA. (Max 1 page)

The project “Effect of the armchair with massage and relaxation program on recovery and health promotion—a randomized controlled study”—is financed by the Knowledge Foundation (3 800 000 SKR) and co-produced with business and the following companies (3 800 000 SKR): PROMAS AB and Scandinavian International University (SIU). These two companies assist with (i.e. recovery chair with massage and relaxations program) (540 000 SKR included in the 3 800 000 SKR financed by the companies).

http://www.kks.se/verksamhet/_layouts/listform.aspx?PageType=4&ListId={BE0839F8-277C-4921-915A-03DACC37E526}&ID=1956&ContentTypeID=0x01008A041F6FAF91624D9A113964FD2B22BF

Promas AB is a company located in Gothenburg, with local offices in other parts of Sweden www.promas.se. The company was founded in 2003 and currently has about 50 employees, including sales and marketing staff, product developers and technicians. Promas AB promotes the concept of recovery in the form of massage combined with mental training. The massage given by the ACM is designed for professional use in a public environment. A treatment takes 15 minutes and provides a medically accurate massage on neck, shoulders, chest back, lower back and calves. Promas AB’s mission is to assist the employer creating healthy workplaces by providing all employees the opportunity to access mental and physical rehabilitation in the workplace. Promas AB estimates that between 30,000 to 35,000 people in Sweden use the concept daily.

Scandinavian International University (SIU) is a private university and a node in a network of companies, which are working mainly with mental training, relaxation, mindfulness and coaching, with a focus on professional development for individuals, leaders, teams and organisations. SIU together

with the collaboration companies develop and produce the programs for mental training and relaxation used in the Concept for Recovery. The main business idea can be summarised as development of professional and personal life competence. All companies are situated in the same building and are owned by Lars-Eric and/or Elene Uneståhl. There are seven employees and seven sub-consultants included in the network. The total turnover is about 7 million SSK per year. The network consists of the following companies: - Scandinavian International University (SIU): www.slh.se org nr: 556402-4627 - Nordic Institute of MTNLP AB: www.nordicinstitute.se org nr: 556687-4912 - Mind Trainer Excellence Sweden AB: www.mtsweden.com org nr: 556767-3347 - International Coach: www.international-coach.com

A4.3 Innovation activities

The UoA describes the most significant innovations during 2007-2012 making an impact (i.e., a change) on society (Max 3 pages). Examples of innovation are products, designs, processes, methods, etc. The innovations can be realized within the university or by a partner and listed at the end (not included in the three pages) and should not be more than 15.

1. Sterile water injections in midwifery: Through the research within the research orientation "WellCam" related to sterile water injection the method has been accepted and its use for pain relief in childbirth has increased in Sweden as well as internationally (Holland, Australia, and Canada).
2. Acupuncture in midwifery: A comprehensive survey related to acupuncture within the obstetrical field (applications, training and guidelines), the use of the method has been a subject of discussion. In addition, research within "HealWell" has also proved that the pain relieving effect during childbirth is very weak. This has resulted in a reduced use of acupuncture in midwifery in Sweden.
3. The perioperative dialogue: A study aimed to evaluate the efficacy of 'the perioperative dialogue' in 5-11 year-old children undergoing day surgery has resulted in: no premedication given routinely to children undergoing day surgery at Skaraborg Hospital. The "Perioperative dialogue" is now used as a complement to standard perioperative care in children undergoing day surgery, especially for those children with increased anxiety. Results of this study have the potential to have a further impact on clinical care, as it is used in all Swedish education for theatre nurses. There are also international examples from King's College (UK) that use publications from this research as course literature.

4. Professional support during childbirth and breastfeeding: This research has had an impact on professional attitudes and support during childbirth and breastfeeding in a positive manner. Due to this, mother's experience, a better professional support. Parental education is conducted during pregnancy and during the babies first year, and the fathers are now also more involved in parental education. These changes in caring routines have resulted in a better collaboration within the continuum of care, for example in both maternity wards and family centres. In addition these caring routines also have a positive impact on mothers' self-esteem, breastfeeding and relations and feelings for the baby, which is positive for the well-being of the whole family. Replication studies have been completed in many places nationally and internationally, and the studies are cited in scientific and popular journals, conferences, and in different stakeholders' documents such as WHO.
5. One study is being developed on behalf of an assignment from a secondary school, and its outcome is at the moment being processed in this educational context for future development of the educational practice. Another study is related to higher education (University of Skövde; teaching at this educational level) and has the character of an action study with a parallel evolutionary process as the interim result emerges. These results form a basis for further data collection and analysis in this collaborative action study. A third study is reported, but no effects/outputs are available here yet. This study continues in the spring of 2013. These practice-oriented research outputs serve as concrete results (back) in the practice/community (school and education mainly), within the framework of the implementation area that is in question. The results are made visible and have a concrete societal impact in that they also include practitioners (mainly teachers) in publications and practice-feedback 'hearings'. This proves to have a direct applicability and usefulness in the current societal/educational practice in and through which results are derived. This type of applicability and applied research provides societal effects that contribute to, and at the same time are an active part of, change and development that benefits people's education and learning related to health and wellness.
6. Research within the milieu has been brought up at the (educational) policy level as part of an on-going review of policies to improve and also effectively evaluate the school's statutory democratic socialisation assignment. The results from this research are mentioned in a report from the National Agency for Education and involves concrete suggestions about how to come to terms with the schools' commissioned assignment to provide for civic competence among young people in comprehensive school. Another concrete impact on (political) society is that researchers

were invited to a meeting of the Nordic Council of Ministers in Oslo in autumn 2012 to give a lecture on the current situation as concerns democracy levels in Swedish teacher education and in Swedish schools, in order to compare this situation with the other Nordic countries. This resulted in a forthcoming report from the Nordic Council of Ministers, where the effects of the input from politicians to ensure young people's (pupils/students) democratic development in school is mapped and constructive advisory services are offered to the on-going school practice.

7. The didactic model, the challenge—to take charge of life with a long-term illness—has attracted attention among both patient associations and representatives within healthcare organisations. The implementation of this model has started in different types of care (primary care, dialysis units).
8. One of the researchers has also been involved in the development and adaptation of the Baby Friendly Hospital Initiative (WHO/UNICEF) focused on neonatal care, which will have implications in promoting breastfeeding in sick and preterm babies.
9. Research dealing with the conceptualisation of the "well-being" and public health issues within "HealWell" has resulted in an invitation to contribute several chapters to the interdisciplinary work, the "Encyclopedia of Human Services and Diversity" (Elsevier), which is a part of the "International Encyclopedia of the Social and Behavioural Sciences". The chapters are "Differing Attitudes Toward Health and Sickness", Lead Author: Ali Kazemi; "Home and Community Services", Lead Author: Diana Stark Ekman and "Nutritional Services and Assessment", Lead Author: Elisabeth Kylberg. This work will be marketed to academic and public libraries as a print and digital product available to students via the library's electronic services.

A5. Self-assessment and future development

In this section the UoA should provide a self-assessment of its present opportunities for improvements. What does the UoA aim to achieve, e.g. in terms of activities within the UoA, external networking, interdisciplinary activities, joint publications and funding?

A5.1 Self-assessment of the UoA

Based on the quantitative data (part B) and qualitative assessment above, list strengths, weaknesses, opportunities and challenges (threats) of the UoA and of the research conducted. Strengths and weaknesses refer to properties of the UoA, whereas opportunities and challenges normally refer to external factors. Propose actions that would improve the quality of the research. Consider both

purely academic factors and factors related to cooperation with external partners.

The UoA must grade, on a scale 1-8, and motivate the premises and ability to

- *recruit qualified staff and PhD students,*
- *attract external research funding,*
- *position the UoA internationally.*

Here, 1 means poor and 8 means excellent. Apply a long-term perspective of the strategic planning of the UoA and what priorities that will be made regarding future research (max 10 pages).

Premises and ability to recruit qualified staff and PhD students

Since the work started with the formation of the research milieu, signs of a new era can be discerned. From actively seeking potential qualified staff to being sought, qualified staff has now started to actively present themselves to us, to research and teach in our educational programs. This new phenomenon is mainly due to their having heard about the research milieu and its orientation in positive terms. This leads to the opportunity for us to employ senior researchers with a research focus within the “HealWell” area. We grade our premises and ability to recruit qualified staff at 5 on a scale 1 to 8

Due the problematic situation in attracting external funding, the premises and ability to recruit PhD students is challenging. However, we have collaborative interdisciplinary research orientations dealing with issues of interest to health care and society. We also have promising collaborations with research groups at other universities with the same research focus. Therefore, we have the potential to succeed in attracting external funding and consequently increase our ability to recruit PhD students. We also have a promising collaboration with the health care sector, which facilitates the possibility of linking funded PhD students to the research milieu (HealWell).

We grade our premises and ability to recruit PhD students at 3 on a scale of 1 to 8

Premises and ability to attract external research funding

Despite intensive activity applying for research funding, the milieu has had severe difficulties attracting research funding/grants. Refusals are often motivated by weak expertise in the research group, despite good rankings on the quality of the projects. Gathering the research and its competences through the formation of an interdisciplinary research milieu (HealWell) with specific research orientations and in addition creating strong collaborations with other research groups with similar research orientations will not only

strengthen the ability to produce research of high quality but also the ability to attract larger grants. We grade our premises and ability to attract external research funding at 2 on a scale of 1 to 8.

Premises and ability to position the UoA internationally

We are a small university; it is difficult to single-handedly create a national leading and internationally recognized research environment. We can however conduct reach in collaboration with other research milieus with similar specialisations. The creation of the research programme “Aging, learning, living” in collaboration with the University of Borås and participation in the creation of a centre for health care research at the University of Gothenburg is in line with this ambition. We have, however, the potential to be a leading international research facility within specific well-defined areas such as sterile water injection and support during childbirth and breastfeeding. In these areas, projects about sterile water injection are already leading national projects. Projects about support during childbirth and breastfeeding are internationally well-known projects and in methodological aspects leading. In both project areas, we have started to expand the research collaboration internationally. We grade our premises and ability to position the UoA internationally at 3 on a scale of 1 to 8.

Strengths: High productivity with relatively high quality, the productivity is also strongly increasing since the formation of the research milieu started. High cost effectiveness (production related to resources). Interdisciplinary research within subjects that comprise the research milieu as grounded similar epistemologically and ontologically, can promote synergy and dynamic development of knowledge that will be for the benefit of all disciplines involved, rather than contribute to conflicts. We have a good opportunity to strengthen competences through internal promotion and external recruitment.

Weaknesses: Lack of senior researchers. Our high dependence on internal funding makes us extremely sensitive to changes in this system of allocation.

Opportunities: A research area that is in the interest of society. Several promising national research collaborations with high potential have also been initiated, including the creation of the research programme Ageing, learning, living, which is a collaboration with the University of Borås. The creation of a centre for healthcare research initiated by the University of Gothenburg, which is a collaboration between the University of Technology, University of Borås, Halmstad University, Jönköping University, University of Skövde, University West, Linköping University, Göteborg Region Association of Local Authorities, Västra Götaland region and the Swedish Institute for Health Sciences.

Threats: Difficulties to attract external research grants are highly dependent on internal research grants. Difficulties in financing PhD students.

Part B: Quantitative data of the UoA

In this part of the evaluation package questions and tables are presented in 3 sections which contain quantifiable information about the UoA in support of the statements made in Part A above.

B1: Research environment and infrastructure

B2: Research output

B3: Impact, engagement and co-operation with society

B1. Research environment and infrastructure

B1.1 Staff statistics

Provide information of the number of individuals and full time equivalents (FTE) of staffs' research activity. The 'M' columns show values for men and 'W' for women. The number of individuals refers to Dec 31st each year, whereas FTE is integrated over the whole year. FTE is only presented for 2011 and 2012.

Table B 1.1.1. Number of and full time equivalents of permanent research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Professor	2		2		2		1		1	1		1
FTE									0.6	0.5		0.5
Assoc. prof. (Lektor and docent)								1		3		4
FTE										0.3		1.1
Assist. prof. (Lektor. forskare)				1	3	3	3	10	2	11	2	12
FTE									0.4	1.6	0.2	3.1
Lecturer (Adjunkt)			2	2		1		3				
FTE												
Total Individuals	2		4	3	5	4	4	14	3	15	2	17
Total FTE									1	2.4	0.2	4.7

¹ Professor denotes persons employed as full professors. Associate professor denotes staff qualified to act as principal advisor for PhD students (docent appointment or similar). Assistant professors denote the rest of staff with a PhD.

Table B1.1.2. Number of and full time equivalents of temporary research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Guest profs												
FTE												
Adjunct profs												
FTE												
Assistant professor												
FTE												
Post-Docs and research assistants				1		1		1				1
FTE												0.6
PhD students ¹	1	7	1	7	1	7	1	8	1	6	1	3
FTE									1	4.8	1	1.6
Total individuals	1	7	1	8	1	8	1	9	1	6	1	4
Total FTE									1	4.8	1	2.2

¹ All temporary employed admitted to PhD studies

Table B1.1.3. Other staff supporting research in UoA												
Year	2007		2008		2009		2010		2011		2012	
Staff	M	W	M	W	M	W	M	W	M	W	M	W
Research assistant/ Technician												
FTE												
Administrator												
FTE												
Total individuals												
Total FTE												

¹ Fixed term and visiting research staff. Staff is included in the research output as well as in the bibliometric analysis.

B1.2 Research funding

Sources of research funding and amounts given to the UoA annually during 2007-2012.

Table B.1.2.1. External funding (spent money in t SEK)						
	2007	2008	2009	2010	2011	2012
Research Councils (VR, FAS, Formas etc.)	518	143	228	380	82	-2
Swedish Foundations (e.g. Wallenberg, SSF, Vinnova, RJ, KK, Swedish Energy Agency etc.)	67	23	901	1638	2111	2216
EU					7	
Other public bodies (e.g. county councils, municipalities, etc.)	134	72	235	169	237	424
Direct external funding from industry.	56				277	
University	661	503	816	562	538	316
Others (please specify) individuals						67
TOTAL	1436	741	2180	2769	3253	3021

Table B.1.2.2. Total Research Funding t SEK						
	2007	2008	2009	2010	2011	2012
Total external funding (from table B.1.2.1.)	1436	741	2180	2769	3253	3021
Faculty funding (governmental funding)	3177	5361	4764	8800	9395	8505
Percentage external funding	31	12	31	24	26	26
Research as competence development						
TOTAL						

B1.3 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during **2011-2012** by permanent research staff.

Table B1.3.1 International networks and collaborations	
Number of collaboration institutions ¹	
Number of research visits abroad (1 week to 1 month duration)	2
Number of research visits abroad (of at least 1 month duration)	
Number of visiting researchers (1 week to 1 month duration)	
Number of visiting researchers (of at least 1 month duration)	
Number of funded international research consortia projects	1

¹ Research collaborations given here are limited to those with joint research grants in excess of 100kSEK/year and/or joint publications with the UoA.

B1.3.2 Name of project granted and role of UoA			
Project title	Funding body	Role (coordinator/partner)	Start year
Breastfeeding counseling in maternity health care	University of Eastern Finland	Co-supervisor Anette Ekström	2010
Breastfeeding attitudes in Scotland (A replication study)	University of the West of Scotland	Co-author Anette Ekström	2010
Womens's perception towards their childbirth right to choose place of birth	University of Cyprus	Co-supervisor Lena Mårtensson	2009
The ICARIS Trial	National Health and Medical Research Council (Australia)	Vice chief investigator Lena Mårtensson	2011
Adolescent girls' health	Linneú's University Skaraborg institute for Research and Development	Co-supervisor Maria Björk, Annelie Johansson Sundler	2010
Didactic model "The challenge – to take charge of one's life with long-term illness	Jönköpings County Council, Ryhov Hospital and Skaraborg Institute for Research and Development	Primary investigator Mia Berglund	2012
Pain assessment in dementia care	Skövde Municipal	Main supervisor Ingrid Bergh and co-supervisor Kristina Ek	2009

B1.3.3 Other major international activities according to the tradition of the research field¹	Total No.

¹Please specify: scientific expeditions, field work etc. and list below including duration
A maximum of five examples in total may be provided.

B1.4. Participation in scientific community

UoAs activities undertaken during 2007-2012 that illustrate high quality leadership interactions with their scientific peers.

B1.4.1 Participation in academic community	Number
Plenary or keynote talk at international conferences	8
Assignment as expert in research councils and foundations	4
Assignment as expert evaluator for position as professor, associate professor (docent) and lecturer	21
Assignment as opponent for PhD thesis	13
Assignment as member of examination board for PhD thesis	24
Assignment as editor or member of editorial board for journal	6
Assignment as reviewer for international journal	100+
Member of national scientific councils	3
Member of international scientific councils	3
Chair of program committee (international conferences)	2
Member of program committee (international conferences)	0

B1.5 Recruitments

Number of recruited research staff, men (M) and women (W) during 2007-2012.

B1.5.1 Recruitments	Number	
	M	W
Recruitments with doctoral degree from another Swedish university		6
Recruitments with a doctoral degree from outside Sweden	1	
Recruitments with doctoral degree from own university		
TOTAL	1	6

B2. Research Output

B2.1 Promotions and degrees

This section quantifies the development of scientific staff during 2007 to 2012 distinguishing men (M) and women (W).

B2.1.1. Doctoral degrees awarded and promotion of researchers												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
No. Doctoral degrees		2	1	5	1	2	1	1		3		5
No. Docent promotions		1				1				2	1	
No. Professor promotions				1						1		
TOTAL		3	1	6	1	3	1	1		6	1	5

B2.2 Publications

Publications and other research output achieved during 2005-2012 to provide the publication profile of the UoA.

Table B2.2.1: Total number of scientific publications produced by the UoA. Please specify citation index in each publication list.										
Publication types	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Article in journal, peer reviewed	9	6	10	13	9	21	39	69	176	22.0
Article in journal, not peer reviewed		1		3	1			1	6	0.8
Article in journal, book review							3	1	4	0.5
Article in journal, review				2	1			1	4	0.5
Book								1	1	0.1
Edited book			2			1	5	9	17	2.1
Chapter in book	1		4	3	6	4	5	14	37	4.6

Conference paper (peer reviewed)	1		1		2	7	13	9	33	4.1
Conference paper (not peer reviewed)										
Thesis, doctoral	1	1	1	3	2		2	3	13	1.6
Thesis, licentiate ¹							1		1	0.1
Thesis, master										
Report				1	2	1		1	5	0.6
Other scientific publication										

¹Licentiate is a Swedish and Finnish academic degree on graduate level corresponding to circa half a Swedish PhD.

Table B2.2.2. Aggregate publication information										
	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Total number of publications in DiVA	12	8	18	25	23	34	68	109	297	37.1
Number of publications in Web of Science	6	5	6	12	7	14	22	37	109	13.6
Number of publications in Web of Science, author fractionalized	2.8	2.5	2.2	5.4	1.9	5.6	7.2	17.6	45.2	5.7

Web of Science visibility (percent of publications included)	50%	63%	33%	48%	30%	41%	32%	34%	37%	-
Scopus visibility (percent of publications included)	58%	75%	44%	60%	39%	50%	31%	45%	44%	-
Journals' field normalized impact	0.96	1.45	1.02	0.9	0.89	0.89	1.01	-	0.98	-
Journal Impact Factor	0.79	2.56	1.19	1.45	1.37	1.45	1.54	-	1.47	-
Norwegian score	11.7	9	14.7	20.7	15.1	23.4	38.2	66.6	199.4	24.9
Norwegian score fractiona-lized	5.3	5.2	7.4	10.1	6.8	12.1	18	34.8	99.8	12.5
Publica-tions in level 1 journal – Norwegian list	8	6	7	14	7	19	31	51	143	17.9
Publica-tions in level 2 journal – Norwegian list	1	1	2	2	2	1	1	3	13	1.6
Publica-tions in level 1 conference – Norwegian list							1		1	0.1

Publications in level 2 conference – Norwegian list										
Publications in level 1 book publishers	1		1	1	3	2	5	8	21	2.6
Publications in level 2 book publishers			1					1	2	0.3

Table B2.2.3. Citation indicators									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Total number of citations	54	52	23	90	37	36	30	-	322

Number of citations, author fractiona-lized	18.8	26.7	7.8	32.5	7.6	9.8	8.4	-	111.6
Citations per publication	9.0	10.4	3.8	7.5	5.3	2.6	1.4	-	4.5
Share of publica-tions not cited	17%	0%	0%	0%	0%	21%	45%	-	19%
Average field normalized citation rate	0.78	0.91	0.45	0.97	0.92	0.59	0.98	-	0.83
Share of publica-tions among the 10 percent most cited in the field	0%	0%	0%	0%	0%	0%	14%	-	4%
Share of publica-tions among the 25 percent most cited in the field	0%	25%	0%	25%	29%	14%	24%	-	19%

Table B2.2.4. Authorship									
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Average authors per publication	3.7	3.6	3.8	3.3	4.7	3.5	3.7	3.5	3.6

Average countries per publication	1	1.4	1.5	1.2	1	1.4	1.2	1.6	1.3
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Table B2.2.5. Role of key scholars									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Share of publications by 3 most active authors	42%	38%	50%	28%	30%	29%	21%	23%	27%

Table B2.2.6. Productivity								
	2007	2008	2009	2010	2011	2012	Total	Annual average
Number of publications in relation to total funding (MSEK).	2.43	2.34	1.86	2.31	4.49	7.65	3.71	3.51
Number of publications in relation to FTEs					7.39	13.46	10.23	10.42
Number of citations in relation to FTEs					3.26		1.73	3.26

B2.3 Innovation output

As well as engaging with society through contract research or education, researchers today sometimes patent their findings, commercializing these through multiple routes. Researchers also form companies either based on patents, or other forms of intellectual property e.g. materials, software or experience. These activities, often referred to as ‘innovation activities’, are listed in the tables below for the years 2007-2012.

B2.3.1. Patents ¹			
Patent number ²	Short description	Person(s)involved at UoA	Date of registration

¹ Data should match that held in DiVA.

² Awarded patents only, not patent applications.

B2.3.2. Founded companies¹				
Company name	Founder(s) from the UoA	Company type	Date of formation	Current status

¹ Included eligible companies must be a direct result of the university's research activities and have, or have had, an annual income in excess of 100kSEK.

B3. Impact, engagement and co-operation in research with society

This section presents activities related to co-operation in research with society and the impact of such activities. It includes the unit's general approach to enable impact and engagement from its research, and also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B3.1 PhD degrees

The number of doctoral degrees (PhD, etc.) earned within the UoA during 2007-2012 when the awardee has been externally employed. Number of men ('M') and number of women ('W') are recorded per year.

Table B3.1.1. Doctoral degrees awarded to students externally employed												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
Number of doctoral degrees												

B3.2 Major research related co-operation with society

Activities regarding research related co-operation with society should be entered into one of three categories in the table below: Table3.2.1 lists mobility between academia and non-academic society, such as exchanged lectures with external (non-academic) organisations, the engagement of adjunct professors, and externally financed PhD students in collaborative research projects with partners from industry or other organisations in society; Table3.2.2 includes the number of publications co-authored with individuals outside of academic institutions, and popular publications aiming at the general public; Table 3.2.3 counts the number of external partners of the UoA separated between SME, large enterprises, and non-industrial partners; Table

3.2.4 summarizes the amount of *in kind* funding from industry and non-industrial organisations in society.

Table 3.2.1: Mobility between academy and society						
	2007	2008	2009	2010	2011	2012
No. of collaborative doctoral students ¹			1	1	2	2
No. of temporary research positions outside university ²						
No. of adjunct researchers						

¹Number of doctoral students in the UoA who are financed by non-academic external partners. Note that this does not mean doctoral students who are financed by any non-academic funding body, but students who are financed by external partners to the UoA (e.g. industry or public sector organisations).

²Permanent UoA personnel who migrate from the university to non-academic society

Table 3.2.2: Outreach activities						
	2007	2008	2009	2010	2011	2012
No. of scientific publications with representatives from society (not academia)						
No. of popular science publications (popular science magazines, including the internet)						

Table 3.2.3: Collaboration organizations (please provide description in A 4.1.)						
	2007	2008	2009	2010	2011	2012
No. of partners from industry (SME) ¹					2	2
No. of partners from industry (non SME)						
No. of partners from society excl. industry and academia	3	3	3	3	3	3

¹enterprise with no more than 250 employee and an annual turnover not exceeding 50 M €.

Table 3.2.4: Indirect external funding (in t SEK)						
	2007	2008	2009	2010	2011	2012
Indirect funding from non-industrial organisations in society (in kind ¹)						

Indirect external funding from industry (in kind)						
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¹ value of working hours done by external partner, value of equipment, databases, software, laboratories etc. that external partners provide in joint research projects.

Part C: Case descriptions

C.1. Impact case

The number of cases required in each submission is two (max.). The case should have been carried out during the period January 1st 2007 to December 31st 2012. Each case must provide details not only of the academic impact e.g. publications in highly ranked journals, but also describe the impact of the excellent research on society.

Table C1.1.2 Template for impact cases (maximum 4 pages)
<p>Title of case: Support and attitudes during childbirth and breastfeeding</p>
<p>Describe and provide evidence of the specific impact, including:</p> <ul style="list-style-type: none"> - an explanation of the nature of the impact, <p>The specific impact of this research area is parents' and health professionals experience of professional support, social support and attitudes in childbirth and breastfeeding. A randomized intervention study of process-oriented education on support during childbearing and breastfeeding for health professionals was performed by Anette Ekström. The intervention changed the professionals' attitudes, mothers' experience of support and the outcomes of breastfeeding in a positive way, which has a great impact for the clinical implementation of research. Another perspective of the research includes observation studies around childbirth, with both from the professional and parental perspective and also how parents to preterm babies perceive being parents during the stay at the neonatal intensive care, where the parents act as caregivers while holding their baby skin-to-skin.</p> <p>In addition, the research group developed scales in order to measure baseline before interventions as well as to measure outcomes after interventions in regard to support and attitudes during childbirth and scales for measuring mothers and fathers' feelings and relations to the newborn infant. These scales are: Mothers' and Fathers' Perceptions of Professional Support from Health Professionals, the Mother/Father-to-Infant Relation and Feeling Scale, and the Breastfeeding Attitudes Instruments.</p> <ul style="list-style-type: none"> - how far-reaching the impact is/who the beneficiaries are <p>Professional support in childbearing is a challenging balancing act meeting</p>

women and/or their partners' psycho-social and physical individual needs. If the challenging balancing act is successful, it increases the chances that the women and/or their partners will not perceive a lack of support. A process-oriented education for health professionals in support during childbearing and breastfeeding contributes to an understanding of how a process-oriented education in support during childbearing and breastfeeding, for antenatal midwives and postnatal nurses, change the health care professionals' attitudes in a positive way; it strengthen the mothers' perception of support from the professionals; and improves the maternal relationship and feelings for the baby. There is also a positive correlation between the preparation for the parental role and a reduced number of infants being given breast-milk substitutes without medical reasons during the first week, as well as a delayed introduction of breast-milk substitutes after discharge from the hospital, if the health professional received the process-oriented education compared with the control groups. Furthermore, increasing the knowledge of a process-oriented education can reinforce the educational impact on the midwifery students' learning and development of professional skills in their education.

The relevance of this research is to increase knowledge about parents' and midwives' experience of professional and social support in connection with childbearing and breastfeeding, and women's perceptions towards their childbirth in order to give good professional support to parents during childbearing. Clinical relevance of the project: having preterm babies skin-to-skin with their parents strengthens changes in routines at neonatal wards, aiming to optimize the well-being of babies and their parents. Another project of clinical relevance is to increase knowledge about the utilisation of health and delivery care and postnatal vitamin supplements to the baby.

-how significant the benefits are

This research has had an impact on professional attitudes and support during childbirth and breastfeeding in a positive manner. Due to this, mothers experience a better professional support. Parental education is conducted during pregnancy and during the babies first year; the fathers are now also more involved in parental education. These changes in caring routines have resulted in education for the professionals, and a better collaboration within the continuum of care, for example in both maternity wards and family centres. In addition, these caring routines also have a positive impact on mothers' self-esteem, breastfeeding and relations and feelings for the baby, which are positive for the well-being of the whole family. The scales contribute to a better understanding of the research areas in order to measure and compare outcomes of interventions. The scales can also contribute to discussions in clinical practice.

Explain how the UoA research activity contributed or led to the impact, including:

- **an outline of what the underpinning research was, when this was undertaken and by whom**

During Anette Ekströms clinical practice as a midwife, the annual report from The National Board of Health and Welfare about breastfeeding duration in Sweden in 1996 showed that the women in the Skaraborg region had the lowest breastfeeding rates in Sweden. In a mapping study done by A Ekström, it was shown that the mothers experienced bad breastfeeding support from the health care chain. Therefore, A Ekström implemented a process-oriented education for healthcare professionals in support during childbirth and breastfeeding where mothers evaluated the offered professional support in a randomized longitudinal study. Elisabeth Hertfelt Wahn and Stina Thorstensson continued in their doctoral studies to contribute further knowledge about the impact of professional support during the childbearing period.

- **what efforts were made by staff in the unit to exploit or apply the findings or secure the impact through its research expertise,**

Researchers in the areas and interdisciplinary healthcare professionals planned and work with the project together with A Ekström in order to produce evidence-based research and professional support during childbirth and breastfeeding. The results from the area have spread to other research questions and new projects have been completed and are planned, in order to further contribute evidence-based research to the clinical practice around childbirth, both nationally and internationally.

- **acknowledgement of any other significant factors or contributions to the impact**

Replication studies have been completed in many places both nationally and internationally, and the studies are cited in both scientific and popular journals, conferences and in different stakeholders' documents such as WHO in the Baby Friendly Hospital Initiative (WHO/UNICEF) to address care during the childbirth period.

The study Breastfeeding and Quality of Care is registered in the CONSORT group (Consolidated Standards of Reporting Trials) Trial registrations: ACTRN12611000354987.

Provide references to:**key research outputs evidencing the impact (list of publications, patents etc.),****Publications in scientific journals**

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- Hertfelt Wahn E, von Post I, Nissen E (2007). "A description of Swedish midwives reflections on their experience of caring for teenage girls during pregnancy and childbirth." *Midwifery* 23(3): 269-78. Epub 2006 Nov 27
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- Ekström A, Nissen E. (2007). Process-Oriented Training in Breastfeeding Attitudes and Continuity of Care Improve Mothers Perception of Support. *Health Education Research Trends*. Nova Publishers. NY.

Publications in professional journals

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- Ekström, A., Bäckström C., Hertfelt Wahn, E. (2011). WABA-newsletter: The newsletter NEWS FROM THE BREASTFEEDING WORLD. Two Sides of Breastfeeding Support - experiences of women and midwives. Volume 9 Number 1, April 2011 issue. http://www.waba.org.my/pdf/mstfnl_v9n1_eng.pdf

Thesis

- Ekström, A. (2005). *Amning och vårdkvalitet/Breastfeeding and quality of care*. Karolinska University Press, Stockholm.
- Hertfelt Wahn, E. (2007). *Teenage childbearing in Sweden : Support from social network and midwife*. Karolinska University Press, Stockholm.
- Thorstensson, S. (2012). *Professional support in childbearing, a challenging act of balance*. Örebro University.
- Laanterä, S. (2011). *Breastfeeding Counseling in Maternity Health Care*. University of Eastern, Finland.

Other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA

- EU Project on Promotion of Breastfeeding in Europe. Protection, promotion and support of breastfeeding in Europe: A blueprint for action. European Commission, Directorate Public Health and Risk Assessment, Luxembourg, 2004.

Table C1.1.2b Template for impact cases (maximum 4 pages)
Title of case Sterile water injections as pain relief for labour pain
<p>Describe and provide evidence of the specific impact, including:</p> <ul style="list-style-type: none"> - an explanation of the nature of the impact, <p>Sterile water injection (SWI) as pain relief, primarily for labour pain, is a non-pharmacological pain relief method. The method is very simple; small amounts of sterile water are injected at the site in which the pain is located. Pain relief most often occurs within minutes and SWI can be repeated as needed. Research by Mårtensson has through randomised control trials, proven its effectiveness to relieve back pain during childbirth. Mårtensson has also conducted several surveys both nationally and internationally regarding the use of SWI in midwifery. This research has resulted in an increased use of SWI in Swedish midwifery care. Mårtensson's research has also contributed knowledge, resulting in a randomized controlled trial (in which she is co-investigator) investigating the impact on caesarean section rates.</p> <ul style="list-style-type: none"> - how far-reaching the impact is/who the beneficiaries are <p>SWI is a good alternative as pain relief for women requesting non-pharmacological pain relief methods. No negative side effects have been shown for either the mother or baby. It is also useful for women in care settings lacking other pain relief methods. Further, it is most valuable for the midwives to offer a complementary evidence-based pain relief method.</p> <ul style="list-style-type: none"> - how significant the benefits are <p>In a meta-analysis, it has been shown that the Caesarean section rate was statistically lower in the SWI group compared to placebo or alternative therapy. It is an inexpensive method and easy to learn.</p> <p>Explain how the UoA research activity contributed or led to the impact, including:</p> <ul style="list-style-type: none"> - an outline of what the underpinning research was, when this was undertaken and by whom, <p>The research about SWI started from a clinical point of view. During Mårtensson's clinical practice as a midwife she got in contact with SWI and identified a need for further research in this area. One urgent need was to develop a less painful way to administer SWI. Three randomized controlled trials were included in her dissertation and the results led to an extensive worldwide interest.</p>

- **what efforts were made by staff in the unit to exploit or apply the findings or secure the impact through its research expertise**

The results from the research regarding SWI in relation to childbirth have spread to other questions about pain relief for severe pain conditions. During clinical observations, there are some indications that SWI could be a good alternative for other kinds of severe pain. Further, there are still questions about the underlying mechanisms of actions, and therefore we have started some collaborations with researchers in the biomedicine area, both nationally and internationally. Altogether some new projects are planned regarding both acute as well as long-term pain conditions.

- **acknowledgement of any other significant factors or contributions to the impact**

There are several factors that contribute to the impact such as the method is non-pharmacological and has not shown any negative side effects for the mother or the baby; the method is inexpensive and very easy to learn to use; and the relation to a decreased risk for caesarean section will probably also decrease other obstetrical complications.

Mårtensson has been invited to participate and design a large randomised clinical trial in Australia with the aim to determine if sterile water injections, as an intervention for back pain in labour, will reduce the intrapartum caesarean section rate. She is vice chief investigator in this project that has been registered at the Australian New Zealand Clinical Trials Registry (No ACTRN12611000221954). The project has been funded with AUD 456.760.00 from The National Health and Medical Research Council.

Provide references to:

- **key research outputs evidencing the impact (list of publications, patents etc.),**

Theses

Mårtensson, L. Sterile water injections and acupuncture as treatment for labour pain. Doctoral thesis, 2006, Department of Obstetrics and Gynaecology, The Institute of Clinical Sciences, The Sahlgrenska Academy at University of Gothenburg

Mårtensson, L. Sterile water injections for labour pain. Licentiate thesis, 2003, Institute for the Health of Women and Children, University of Gothenburg

Scientific publications

Lee, N. Mårtensson, LB. Homer, C. Webster, J. Gibbons, K. Stapleton, H. Dos Santos, N. Beckman, M. Gao, Y. & Kildea, S. (2013) Impact on Caesarean section rates following injections of sterile water (ICARIS): a multicentre randomised controlled trial. BMC Pregnancy &

Childbirth, 13:105. doi:10.1186/1471-2393-13-105

Mårtensson, L. The patient observer: Sterile water injections for labor pain. *BIRTH* (2010) 37:4:334-336.

Mårtensson, L. & Wallin, G. (2008) Sterile water injections as treatment for low back pain during labour – A review. *Australian and New Zealand Journal of Obstetrics and Gynaecology*, 48:369-374.

Mårtensson, L. McSwiggan, M. & Mercer, JS. (2008) American Nurse Midwives' Knowledge and Use of Sterile Water Injections for Labor Pain. *Journal of Midwifery & Women's Health*, Mar-Apr, 53:115-122.

Mårtensson, L. Stener-Victorin, E. & Wallin, G. (2008) Acupuncture versus subcutaneous injections of sterile water as treatment for labour pain. *Acta Obstetrica et Gynecologica Scandinavica*, 87: 171-177.

Mårtensson, L. & Wallin, G. (2006) Use of acupuncture and sterile water injections for labor pain: A survey in Sweden. *BIRTH*, 33(4).

Mårtensson, L. Nyberg, K. & Wallin, G. (2000) Subcutaneous versus intracutaneous injections of sterile water for labour analgesia: a comparison of perceived pain during administration. *British Journal of Obstetrics and Gynaecology*, October, Vol 107, pp. 1248-1251.

Mårtensson, L. & Wallin, G. (1999) Labour pain treated with cutaneous injections of sterile water: a randomised controlled trial. *British Journal of Obstetrics and Gynaecology*, July, Vol 106, pp. 663-637.

- **other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA**

There is one meta-analysis in which it was shown that the Caesarean section rate was statistically lower in the SWI group compared to placebo or alternative therapy (Hutton, EK., Kasperink, M., Rutten, M., Reitsma, A. & Wainman, B. (2009) Sterile water injection for labour pain: a systematic review and meta-analysis of randomised controlled trials. *BJOG*, Published Online 14 May 2009.

The Royal Dutch Organisation of Midwives have during several years been in contact with Mårtensson to learn about the method and also acquire evidence-based knowledge in order to get the Dutch Ministry of Public Health to give Dutch midwives permission to use the method during childbirth. We have two contacts in the Netherlands that can describe what kind of impact this has had in the Netherlands and for The Royal Dutch Organization of Midwives.

Josien de Boer, PhD, Scientific advisor/ Guideline developer, phone: +31621501629 and e-mail: jdeboer@knov.nl

Mieke Aitink, MSc, Policy advisor professional development, phone: +31612776846 and e-mail: maitink@knov.nl

Any aspect the UoA wants to highlight

HEALTH AND WELL-BEING - INDIVIDUAL AND SOCIETY During the past two years, intensive efforts have been made to create a coherent research orientation and collaboration among researchers within as well as across different scientific areas. During this on-going consolidation of the research area Health and Well-being (HealWell), researchers have moved back and forth between the groups. The reason is that some of them have overlapping competences, which means that it also takes some time to consolidate the research focus on an individual level. This could also be a strength as it promotes collaboration between researchers in the groups, which will give the HealWell research program better stability.

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UNIVERSITY
OF SKÖVDE

Self-assessment

The Informatics Research Centre

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ARC13 – Evaluation Package

Introduction

The following document describes the research and collaboration of defined units of assessment (UoA) at the University. The document includes indicators on research activities, research initiatives and collaboration in research in relation to academic, business, or public partners. The document also includes a qualitative self-assessment of the strengths, weaknesses, opportunities and threats (SWOT) of the UoA. The indicators aim to describe research activities in specific areas as well as in multi-disciplinary fields. Apart from direct research quality assessments, a number of different aspects are requested to be elucidated; description of the research field, research environment and infrastructure, research output, impact, engagement and co-operation with society (which in this document denotes organisations within business and public sector, non-governmental organisations, the public, but not including other academic institutions) and opportunities for renewal and actions for successful development. The document also includes two case descriptions identified by the UoA as particularly important or significant (see C). The document is structured in three parts:

Part A – Strategic information about the UoA (general description and SWOT-analysis)

Part B – Quantitative data describing the UoA (general information, research output and co-operation with society)

Part C – Case descriptions (two impact cases)

The parts are complementary. Information provided in either part should be used to support and deepen the information presented in the other.

*ARC13 generally assesses the period January 2007 to the end of December 2012 (see appendix 1), although some of the indicators cover a shorter period of time. The expert panels are asked to assess the quality of research (and collaboration) at the UoA in an international perspective based on the instructions given in the Terms of reference (Appendix 1). In particular, the panels are asked to identify **strong research activities, strong collaboration with society** and **potentially interesting opportunities for development**.*

PART A: 1

Part A: Strategic information from the unit of assessment (UoA)

In this part of the evaluation package the UoA communicates information on organisation, co-operation and strategies chosen to ensure that relevant, high-quality research is conducted.

Table 0 – Name of the UoA	
Name of Unit of assessment	INFORMATICS
Coordinators of Unit of assessment	Björn Lundell & Jessica Lindblom

A1. Description of the research in the UoA

This is an overview of the current research areas, including primary missions and goals, within the UoA. (Max 4 pages, in template format):

The Informatics Research Centre (hereafter IRC or the centre) conducts research and education (from undergraduate to doctoral level) in the field of Informatics, focusing on the development and use of information technology (IT) systems for the benefit of man and society. IRC defines Informatics as “*the scientific study of how information is represented, processed and communicated in artificial and natural systems. It also addresses how IT systems are used and developed to ensure usefulness for individuals, organizations, or society*”.

The centre was established by the University Board in 2007. The University of Skövde has since the early 1990s systematically developed an integrated approach of research and education in Informatics that combines and integrates the various aspects of this interdisciplinary field. In 2010, the University of Skövde was approved by the Swedish Higher Education Agency to award degrees at the doctorate level in the field of Informatics (see further section A3.1). This was an outcome of a long history of successful international and national collaboration with other universities (e.g. in the U.K: Exeter and Sheffield, and in Sweden: Linköping and Stockholm) concerning research education. The mission for IRC is to:

- Conduct research and research education of high international standing in the field of Informatics, focusing on development and use of information technology (IT) for the benefit of man and society,
- Constitute an attractive and innovative research environment for ambitious researchers and Ph.D. students,

- To conduct basic and applied research in close collaboration with companies and public sector organisations, which attracts national and international financial support.

The centre has a broad view on the field of Informatics, which has established opportunities for conduction of focused and interdisciplinary research from a number of different theoretical and methodological bases, involving computational, cognitive, and socio-technical perspectives. Research within the centre focuses on different aspects of Informatics, and is organised in five research groups (see further section A3.1):

- The Distributed Real Systems Research Group (DRTS)
- The Information Systems Research Group (IS)
- The Interaction Lab (iLAB)
- The Skövde Artificial Intelligence Lab (SAIL)
- The Software Systems Research Group (SSRG)

Research activities within IRC address different aspects of Informatics, and novel results have been achieved and disseminated in a number of different fora of high international standing. For many years, researchers within the centre have contributed to scientific advancements in the field of Informatics by means of developing research results in a number of different focused areas of Informatics.

Collaborative research activities involving IRC researchers

A major research effort involving many IRC researchers is the Information fusion research programme (2005–2011) *Infofusion – Information Fusion from Databases, Sensors and Simulations*. In this programme, IRC researchers collaborated with a number of companies e.g. with several divisions of SAAB AB in projects dealing with anomaly detection within the surveillance, security and defense domains. Research within the programme has emerged as leading in its area in the Swedish Information fusion community. Programme director, Prof. Sten F. Andler. The Infofusion programme was financially supported by the Knowledge Foundation¹ and industry.

¹ The Knowledge Foundation (KK-stiftelsen) is the research financier for universities with the task of strengthening Sweden's competitiveness and ability to create value.

Researchers within the centre have had leading roles in a number of international and national research projects. International research (EU FP and EUREKA) projects include:

- The FP6 ICEA project (2006-2009) *Integrating Cognition, Emotion and Autonomy* – was an integrated project on biologically inspired robotics and brain-based cognitive architectures. Researchers representing IRC focused on cognitive-affective neuro-computational architectures. Coordinator and main applicant, Prof. Tom Ziemke.
- The ITEA project COSI (2006-2009) – *Co-development using inner & Open source in Software Intense products*. Researchers representing IRC investigated the Open Source development model, with a specific emphasis on its potential for adoption in the embedded systems industry. Technical manager, Dr. Björn Lundell.
- The EUREKA EuroStar project SmallBuild+ (2012-2014). The project addresses how enterprise/business modeling and methods from business management and process management can be combined into a comprehensive management system that helps SME construction companies to ensure profitability and hinder bankruptcies. This involves how such a management system can be effectively implemented in SME construction companies so that best practice business processes and business management are seamlessly integrated. The conduction of the project involves a number of Norwegian construction companies. Scientific coordinator, Prof. Anne Persson.

National research projects with project leaders and coordinators from IRC include:

- The TOFFEE Project (2008-2011) – *Tjänster för OFFEntlig Effektiv handel* (in English: E-services in public sector purchasing) – focused on refinement and testing of a computerised product catalogue with associated e-services. Financially supported by VINNOVA². Lead by: Prof. Anne Persson and Dr. Eva Söderström.
- The EKLär project (2004-2007) – *Efficient Knowledge Management and Learning in Knowledge Intensive Organisations* – focused on the implementation and testing of an organizational method to capture, package and share best practices in the area of treatment and prevention for leg ulcers, as well as to build a knowledge repository to support the knowledge sharing process. The project was nominated to

² The Swedish Governmental Agency for Innovation System.

the prize Guldskalpellen 2008, innovator of the year in Swedish health care. The prize is awarded by the Swedish health care magazine Dagens Medicin. Financially supported by VINNOVA. Lead by: Prof. Anne Persson.

- The VFI project (2008-2010) – *Vårdens Framtida Information – vision i form av en demonstrator* (in English: Supporting active patient and healthcare collaboration – a prototype for future healthcare information systems). The project developed a prototype for visualisation of a process support system (PSS) demonstrating requirements for future process-oriented information systems support in healthcare. Financially supported by Region Västra Götaland. Lead by: Prof. Anne Persson and Dr. Rose-Mharie Åhlfeldt.
- The project – *New approaches for game based training* – (2009-2011) investigated how games and game technology can be utilised for training and education of rescue services personnel. The project evaluated the usage of game based training in rescue services education. The aim was to develop a set of best practices for game based training. Financially supported by the Swedish Civil Contingencies Agency. Lead by: Dr. Per Backlund.
- The O.S.A. project (2008-2010) – *Open Source Action in Swedish Organisations* – focused on knowledge improvement within organisations in order to increase competitiveness and health within the Swedish OSS ecosystem. Financially supported by the Knowledge Foundation and industry. Lead by: Dr. Björn Lundell.
- The ORIOS project (2012-2015) – *Open Source software Reference Implementations for Open Standards* – aims to develop a reference model of necessary and desirable features of an Open Standard, and how Open Standards and their implementations can be utilised by small companies in different usage contexts. Financially supported by the Knowledge Foundation and industry. Lead by: Dr. Björn Lundell.

Researchers within the centre have been involved as partners in a number of international and national research projects. International (EU FP and EUREKA) research projects include:

- The FP7 STREP project ROSSI (2008-2011) – *Emergence of communication in Robots through Sensorimotor and Social Interaction* – focused on sensorimotor and social interaction (human-humanoid) and concept/language grounding. Researchers representing IRC focused on neuro-computational/dynamic-field-theoretical models of the mirror neuron system as well as action segmentation.

PART A: 5

- The FP7 STREP project NeuralDynamics (2011-2015) – *A neuro-dynamic framework for cognitive robotics: Autonomous generation of scene representations and behavioral sequences using online learning.* Researchers representing IRC focus on motivation, the organization of sequential behaviour and goal-directed sequence generation.
- The FP7 Marie Curie initial training network ROBOT-DOC (2009-2013) – *Robotics for Development of Cognition* – focuses on developmental cognitive/humanoid robotics. Researchers representing IRC focus on affective/emotional/motivational mechanisms in (humanoid) cognitive/developmental robotics.
- The ITEA2-project MoSiS (2008-2010) – *Model-driven development of highly configurable embedded Software-intensive Systems* – in which IRC researchers focused on introducing and evolving Model Driven Development in industrial settings.
- The ITEA2-project OPEES (2009-2012) – *Open Platform for the Engineering of Embedded Systems* – aimed to establish a community and build the necessary means and enablers to ensure long-term availability of innovative engineering technologies in the domain of critical software-intensive embedded systems.

Researchers within the centre have been involved as partners in a number of national research projects. National projects include:

- The DOME project (2012-2013) – *Deployment of Online Medical records and E-health services* – the project aims to build up knowledge about the implementation and use of e-health services based on studies of e-health projects. Financially supported by VINNOVA.
- The SOMWeb project (2004-2006) – *Net-based Knowledge-management Supporting Clinical Medicine* – the project focused at managing clinical knowledge, with the intention to provide a foundation for evidence based oral medicine. Financially supported by VINNOVA.
- The project "öppna praktiker" (2009-2013) conducts fundamental research on open practices and aims to advance theory by drawing from analysis of such practices in different domains (media, pharma and Open Source software). Financially supported by FAS (Swedish Council for Working Life and Social Research).

Further, as the field of Informatics is considered strategically important for the University of Skövde, (see "Utvecklingsplan 2012-2016" [In Swedish] Dnr HS 2001/343-111); there are also a number of on-going long term internally funded research and competence development activities.

A2. Summary of the scientific results

This qualitative summary of the most important scientific results of the UoA should reflect the width of the research and make reference to no more than 30 publications (Table A2.1) and other research outputs (Table A2.2). The summary should include comments to the publication and citation profile as presented in section B2.2, including the coverage of output from staff no longer affiliated to the UoA.

Researchers within the centre have an ambition to publish research results in internationally recognised journals and conferences of high standing. In addition to dissemination through top journals and conferences in the specific focus areas for different researchers and projects in the centre, there has also been an ambition to publish results in more specialised fora which are relevant and of strategic importance for advancements of the centre. On a regular basis, researchers in the centre publish research results in a number of academic conferences of high international standing (recognised by ACM, IEEE, IFIP etc.).

Further, researchers in the centre have been involved as chairs, organisers, and editors for proceedings published from a number of internationally recognised academic conferences, including:

- The International Conference on Advanced Information Systems Engineering (CAISE),
- The International Conference on Open Source Systems (IFIP WG 2.13, OSS)
- The Working Conference on the Practice of Enterprise Modeling: from Business Strategies to Enterprise Architectures (IFIP WG 8.1, PoEM),
- The International Working Conference on Requirements Engineering: Foundation for Software quality (REFSQ),
- Simulation of Adaptive Behavior (SAB),
- IEEE Conference on Cognitive Methods in Situation Awareness and Decision Support³ (CogSIMA).

³ Editorial duties conducted during 2012, although the conference was held in 2013.

In addition to proceedings edited by researchers within the centre that have been published by recognised academic publishers from these conferences, researchers within the centre have also organised and hosted a number of international workshops in different areas of Informatics. Some researchers within the centre have also received international recognition for their involvement in the scientific community. For example, the IFIP Outstanding Service Award 2012 has been awarded to a researcher within the centre.

Publications from research activities conducted at the centre include papers published in four recognised top⁴ journals (*Artificial Intelligence*, *IEEE Transactions on Software Engineering*, *Information Systems Journal*, and *Journal of Medical Internet Research*) in different areas of the field of Informatics. In addition to publication in these top journals, research results from the centre are also published in three additional journals which have high⁵ impact factors (*ACM Transactions on Software Engineering and Methodology*, *Information Fusion*, and *IEEE Software*). Further, several publications from the centre are highly cited and there are some contributions which have attracted more than 100 citations.

In addition, research results from the centre are also published in several other ISI rated academic journals, including: *Behavioural & Information Technology*; *BioSystems*; *Empirical Software Engineering*; *Governmental Information Quarterly*; *Information and Software Technology*; *Journal of Systems and Software*; *Manufacturing Robotics and Computer-Integrated Manufacturing*; *Requirements Engineering*; and *Software Testing, Verification and Reliability*. Further, it is important to acknowledge that research results from the centre are also published in, relatively, new journals which are not yet indexed by Thomson.

In summary, of the 25 publications listed (in Table A2.1), totally seven (7) publications have an impact factor above 2 (when considering 5-Year Impact Factor for the specific publication year) according to ISI Thomson Rating, and several are highly cited (e.g. a publication in the journal *Software Testing, Verification and Reliability* have more than 100 citations). Further, most publications (except a few published recently, 2011 or 2012) are cited more than ten times. It should also be noted that the vast majority of the 25 publications listed (in Table A2.1) are authored (or co-authored) by researchers currently active in the centre.

⁴ These have an impact factor above 3 (when considering 5-Year Impact Factor for the specific publication year) according to ISI Thomson Rating.

⁵ These have an impact factor above 2 (when considering 5-Year Impact Factor for the specific publication year) according to ISI Thomson Rating.

In addition, there are also a number of other major research outputs from the centre (see further Table A2.2).

Table A2.1. Selected peer-reviewed publications¹

Agerfalk, P., Fitzgerald, B., Holmström, H., Lings, B., Lundell, B. & Ó Conchúir, E. (2005). Framework for considering Opportunities and Threats in Distributed Software Development, In <i>Proceedings of the International Workshop on Distributed Software Engineering (DiSD 2005)</i> , held in conjunction with the 13th IEEE International Requirements Engineering Conference, Paris, 29 August, Austrian Computer Society, pp. 47-61.
Alenljung, B. & Persson, A. (2008). Portraying the Practice of Decision-making in Requirements Engineering – A Case of Large Scale Bespoke Development, <i>Requirements Engineering Journal</i> , 13(4), ISSN 0947-3602, pp. 257-279.
Andler, S.F., Brohede, M., Gustavsson, S. & Mathiason, G. (2007). DeeDS NG: Architecture, Design, and Sample Application Scenario. In Lee, I., Leung, J.Y-T., and Son, S.H. (Eds.) <i>Handbook of Real-Time and Embedded Systems</i> . CRC Press ISBN 1584886781.
Chersi, F., Thill, S., Ziemke, T. & Borghi, A. M. (2010). Sentence processing: linking language to motor chains. <i>Frontiers in Neurobotics</i> , 4(4). doi: 10.3389/fnbot.2010.00004
Dahlbom, A. & Niklasson, L. (2007). Trajectory Clustering for Coastal Surveillance, <i>Proceedings of the 10th International Conference on Information Fusion (FUSION 2007)</i> , Québec, Canada, July 9-12, ISBN: 978-0-662-45804-3.
Dahlstedt, Å. G. & Persson, A. (2005). Requirements Dependencies– state of the art and future challenges. In Aurum, A. and Wohlin, C. (Eds.) <i>Engineering and Managing Software Requirements</i> (pp 95-116). Springer Verlag.
Falkman, G., Gustafsson, M., Jontell, M. & Torgersson, O. (2008). SOMWeb: A Semantic Web-based System for Supporting Collaboration of Distributed Medical Communities of Practice. <i>Journal of Medical Internet Research</i> 10(3): e25.
Froese, T. & Ziemke, T. (2009). Enactive artificial intelligence: Investigating the systemic organization of life and mind. <i>Artificial Intelligence</i> , 173, 466-500.
Grindal, M., Lindström, B., Offutt, J. & Andler, S. F. (2006). An Evaluation of Combination Strategies for Test Case Selection. <i>Empirical Software Engineering</i> , 11(4), 583-611.
Grindal, M., Offutt, J. & Andler, S. F. (2005). Combination Testing Strategies: A Survey. <i>Software Testing, Verification, and Reliability</i> , 15(3), 167-199.
Karlsson, L., Dahlstedt, Å.G., Regnell, B., Natt och Dag, J., & Persson, A. (2007) Requirements engineering challenges in market-driven software development - An interview study with practitioners. <i>Information and Software Technology</i> , 49 (6), 588-604.
Lindblom, J. & Ziemke, T. (2006) The social body in motion: cognitive development in infants and androids. <i>Connection Science</i> , 18 (4), 333-346.
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¹ Publications should be listed in Harvard format. DOI=The Digital Object identifier system, for scientific publications is added in the following format: DOI: 10.1016/j. tibtech.2007.05.002 As a service for the expert panel, the listed publications are available to the expert panel as pdfs. Where the publication takes the form of a book, two copies should be provided.

Table A2.2. Other major research outputs¹			
Type of output	Main person responsible	Description	Date when became publicly available
Integrated platform	Jonas Mellin	Bacon: Simulation platform	2012
Demonstrator	Henrik Engström	The Elinor console is a game-based platform for game-based stroke rehabilitation	2009
Open source code and platform for carrying out experiments (released under LGPL v3)	Anders Dahlbom	DESIRER: Development Environment for Situation REcognition Research Available at: http://sourceforge.net/projects/desirer/ http://desirer.sourceforge.net/	April 2010
Software library in Java for algorithm performance testing intended for science/research	Fredrik Johansson	SWARD (System for Weapon Allocation Research and Development) is a test bed for benchmarking weapon allocation algorithms against each other. It is intended for researchers within operations research, information fusion, and related areas. Available at http://sourceforge.net/projects/sward/ (licenced under the BSD licence)	November 2009
Research documents	Hanife Krasniqi, Anne Persson	Through analysis of existing Swedish knowledge portals containing healthcare information a number of challenges have been identified that need to be addressed for future developments.	October 2012

Research outcome from the VFI-project	Anne Persson, Rose-Mharie Åhlfeldt	<p>The project Supporting Active Patient and Healthcare Collaboration - A Prototype for Future Healthcare Information Systems aimed to develop a visualisation of a process support system (PSS) demonstrating requirements for future process-oriented information systems support in healthcare. The PSS was developed in close collaboration between researchers and practitioners in the Region Västra Götaland, Sweden. The project selected a model healthcare process that repeats throughout the healthcare system and that can demonstrate patient and healthcare communication; initiating, planning, carrying out and following up a patient's visit to a healthcare provider. In addition to already published results in the form of a prototype, the entire research project demonstrated challenges and opportunities for future health care information systems. These have been published in a Swedish report and are the basis for an on-going scientific publication as well as national project.</p> <p>Final report: Persson, A., Hedström, K., Jäger, K., Krasnizi, H., Linderöth, H., Nohlberg, M., and Åhlfeldt, R-M. (2011) Vårdens framtida informationssystem – Vision i form av en demonstrator.</p>	May 2011
Health portal for leg ulcers	Anne Persson	<p>A method and a tool for packaging and disseminating knowledge in and between health care organizations was developed, as well as a web-based knowledge portal using the method and tool. The portal more specifically targeted the diagnosis and treatment of leg ulcers. Since the project ended in 2007 the method and tool has become an integral part in the healthcare organizations involved. It has also been refined in a number of iterations. Available at (in Swedish): http://www.vgregion.se/skassarwebben</p>	2007

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Tactical Incident Commander	Per Backlund	Tactical Incident Commander is a web based application for training strategic decision making. The application is intended to be used in the training of incident commanders and has been developed in cooperation with the Swedish Civil Contingencies Agency	2011
EduGameLab serious games database	Per Backlund	The EduGameLab database is intended to collect information and experiences of using games in various education contexts. Teachers can describe how they have used games in educational contexts and review these games with respect to their usefulness for various purposes. The database is available on: http://edugamelab.hosting.his.se/sgdb/	2012
Final research report	Eva Söderström	Final report documenting the project results from the TOFFEE project. Results include a procurement process analysis, planning, development and implementation of a product catalogue and associated e-services, as well as method development.	November 2011

Contributions to establishment of an Open Source community related to the ArCon Open Source project.	Björn Lundell	<p>An important outcome from a long-term collaborative research activity with Combitech AB, undertaken over a series of projects (including the ITEA-project COSI and the ITEA2-projects MoSiS and OPEES), and in particular we have contributed to establishment and promotion of the ArCon Open Source project as part of our activities in the OPEES project. The ArCon Open Source project is initially established as an Eclipse labs project (http://code.google.com/a/eclipseorg/) and the ArCon project is also "a proposed open source project under the PolarSys Container Project." (http://eclipse.org/proposals/polarsys.arc). Hence, the ArCon project will constitute an open source component in the offering of Eclipse IWG PolarSys (www.polarsys.org). The ArCon Open Source project is also in the process of becoming part of the release train in the Eclipse platform (http://eclipse.org/proposals/polarsys.arc) (www.eclipse.org).</p>	December 2011
Research report	Backlund, P., Engström H., Johannesson, M., Lebram, M. et al.	<p>The report presents a prestudy concerning a simulator training center for pre-hospital care. The work has been carried out in cooperation with the local ambulance unit and the regional hospital Skaraborgs sjukhus.</p> <p>Backlund, P., Engström H., Johannesson, M., Lebram, M. m.fl. (2013) Ambulansträningscenter. Förstudie prehospitalt tränings- och simuleringscenter för Västra Götaland. Teknisk rapport HS-IKI-TR-13-001. Available via: http://www.his.se/forskning/forskningscentrum/informationsteknologi/ingame-lab/publications-and-dissemination/</p>	Conducted 2012 (report published in January 2013)

Contributions to establishment of PolarSys, an industrial working group within Eclipse Foundation.	Björn Lundell	PolarSys (www.polarsys.org) is an Eclipse Industrial Workshop Group (IWG) which is an outcome of a joint effort undertaken by partners in the collaborative research project OPEES (http://www.eclipse.org/org/press-release/20111102_polarsys.php). The formation of PolarSys is an outcome of a recognised need from a number of large industrial organisations (http://polarsys.org/members), and the University of Skövde has contributed to its formation and after its establishment also been invited to join as an academic partner in PolarSys (www.polarsys.org).	November 2011
Development of a demonstrator for process control based on an Open Source-licensed solution	Thomas Fischer	An Open Source-licensed process control system (www.proview.se) has been deployed in a manufacturing plan process simulator. The demonstrator is a joint collaboration with researchers in the Industrial Automation research group.	September 2010
An Open Source-licensed Web solution for conference registration and payment (referred to as PernillaSys).	Henrik Gustavsson	A conference registration system developed for the International Conference on Open Source Systems (OSS 2009, www.oss2009.org) has been used to support the organisation of several conferences and events, both within and outside the UoA (https://launchpad.net/perillasys). The system is deployed as an Open Source project on an open platform in order to promote open innovation, and so far it has been adopted and used by organisations outside the UoA and outside the University of Skövde.	February 2009

Open-source library for working with Dynamic Field Theory.	Boris Duran	Open-source optimized C++ library for working with Dynamic Field Theory (badDFT), developed in FP7 project NeuralDynamic. Available at: http://sourceforge.net/projects/baddft/	May 2012
Rat's Life robot programming contest and simulation environment	Anthony Morse (now Plymouth), Tom Ziemke	A freely available Webots-based simulation environment originally developed in FP project ICEA, which for a couple of years was used as a benchmark for robot programming contests, student course work, etc. Available at: http://www.ratslife.org/ ; online contests are no longer run by us (ICEA ended December 2009), but the software/simulation is still available and has become part of the free Webots robot simulation software.	October 2008
Research report	Paul Hemeren Mikael Johansson , Mikael Lebram, Fredrik Eriksson, Kristoffer Ekman, Peter Veto	The URBANIST project, intention prediction of cyclists in traffic. Available at: http://www.lansforsakringar.se/privat/om_oss/lansforsakringsgruppen/forskning_o_framtid/avslutade_projekt/Documents/rappport-uppmarksamhet-hos-bilforare-i-mote-med-oskyddad-trafikant.pdf	Work conducted 2012, final draft December 2012
The Human Brain Project – A report to the European Commission	Serge Thill & Tom Ziemke (among 100+ other authors)	This is an intermediate report (http://www.humanbrainproject.eu/files/HBP_flagship.pdf), from the preparatory study for the Human Brain Project, one of the two successful European FET Flagship proposals that will be funded over the next 10 years. The iLab at IRC is one of 100+ partners in this project.	April 2012

¹ There is a maximum number of research output submissions allowed. The number of key research outputs, whether publication or other research output, is limited to the total number of professors within a UoA multiplied by four. The number should be four in case the UoA does not have a professor. Internationally acknowledged research outputs such as new materials, products and processes, patents, software, computer code, standards documents, evidence synthesis including systematic reviews, analyses, meta-analyses, research-based clinical case

studies that add new knowledge, physical artefacts such as images, materials products and processes, prototypes, digital artefacts such as datasets, software, film and other non-print media etc.

A3. Research environment and infrastructure

In this section, the UoA presents the research environment that constitutes the context and breeding ground of its research.

A3.1 Organisation of the UoA

A description of how the UoA is organised; how research is managed and quality-secured; a presentation of research groups; how efforts of fund-raising are structured. (Max 2 pages for UoA and an additional ½ page per group)

Research activities within IRC are coordinated by its steering group, encompassing the research group leaders and professors within the field of Informatics. The steering group is chaired by Prof. Tom Ziemke and co-chaired by Associate Prof. Björn Lundell. There are regular meetings for addressing strategic and coordination issues of relevance for the centre. A number of joint activities are organized on a regular basis by IRC, such as bi-weekly research seminars and “the IRC days”. The on-going series of research seminars provide an opportunity for visiting researchers to present and get exposure of their research ideas, as well as an opportunity for IRC researchers to communicate research results at an early stage in specific projects. “The IRC days” constitute an opportunity for IRC researchers to present and participate in intense discussions with other researchers in the centre. Such discussions create an opportunity for increased awareness of on-going research activities and promote initiatives for inter-group collaboration among researchers within the centre.

Strategies used for managing and organising an effective way of working for conduction of fund-raising and research activities can be characterised as informal and agile, and highly influenced by the specific nature of the domain for the research with its inherent conditions and expectations for conduction of high-quality collaborative research in the specific focus of Informatics. The person responsible for each group is responsible for the overall management of the specific research group. This, however, does not include direct management of the other group members. Instead the group leader has the more informal role of making sure that the group develops by actively participating or encouraging the group members to take active part in various

applications and projects, thereby fostering the academic growth of junior researchers in the centre.

In addition, publishing research findings from project activities in scientific and practitioner fora is an on-going activity and a strategy which contributes to securing quality in outcomes from research efforts undertaken by researchers in the centre. For example, specific research results are often initially submitted to a relevant peer-reviewed conference, followed by submission of revised work to peer-reviewed journals (and sometimes a tailored version of the results may also be submitted and disseminated through relevant practitioner fora).

Several researchers within the centre are regularly serving on thesis committees at a number of Swedish and international universities, and such involvement provides an important contribution to long-term development of networks and quality assurance of activities within the centre. For example, involvement of IRC researchers as opponents and examiners in Ph.D. defences at other Swedish universities include: Blekinge Institute of Technology (BTH), Stockholm University, Linköping University, Lund University, Uppsala University, and Örebro University. Further, involvement of IRC researchers as opponents and examiners in Ph.D. defences at universities in other countries include: France, Greece, Ireland, the Netherlands, Norway, Spain, Switzerland, and the U.K. These involvements provide international exposure of the centre and bring insights into expectations of Ph.D. processes and its expected contributions in different contexts. Together, these involvements bring valuable experience to the centre.

A3.1.1 Research education

Since the beginning of the 1990s, the University of Skövde has systematically strived to strengthen its research in Informatics. Over the years, a number of Ph.D. students have been affiliated and actively contributed to the IRC research environment. However, although Ph.D. students have been supervised by personnel employed at the University of Skövde, they have been formally enrolled at other universities and consequently been awarded their degree elsewhere. In many cases such arrangements have been part of a long term international and national relationship and collaboration of strategic importance for the centre. For example, a number of Ph.D. graduates have had Professor Jeff Offutt (George Mason University) and Professor Sang H. Son (University of Virginia) as their co-advisor. In addition, researchers within the centre have also initiated and contributed to a number of other research education activities related to specific focus areas of Informatics:

- ARTES – *A Network for Real-Time Research and Graduate Education in Sweden* – financially supported by the Swedish Foundation for Strategic Research (“Stiftelsen för strategisk forskning”, SSF).
- CUGS – *the National Graduate School in Computer Science*.
- SweCog – *the Swedish Graduate School in Cognitive Science* – financially supported by the Swedish Research Council (“Vetenskapsrådet”).
- NOSS (a Nordic Open Source Software Research Education Network), financially supported by NordForsk.

Further, senior researchers have also been active as chairs and editors for Ph.D. summers schools and doctoral consortia organised in conjunction with international academic conferences.

Since 2010, the University of Skövde has the right to issue degrees on a doctoral level in the area of Informatics. Soon after, the industrial research education programme Applied Information Technology (ApplyIT) was established with Ph.D. students in the programme initiating their studies in 2012. ApplyIT focuses on illustrating how advances in the areas of Informatics can be used to implement information technology systems that are beneficial for individuals, organisations and society, as well as the socio-technical and organisational aspects incorporated in order to develop useful systems. ApplyIT is financially supported by the Knowledge Foundation.

A3.1.2 Research groups within IRC

Currently, IRC consists of the following five research groups:

- The Distributed Real-Time Systems Research Group (DRTS)
- The Information Systems Research Group (IS)
- The Interaction Lab (iLAB)
- The Skövde Artificial Intelligence Lab (SAIL)
- The Software Systems Research Group (SSRG)

In addition, during autumn 2012, the IRC steering committee received a proposal from a tentative research group - Media, Technology and Culture (MTEC) which was accepted (2012) for incorporation (2013) in the centre. With the incorporation of MTEC within IRC we envisage new opportunities for inter-group collaboration. The research focus for MTEC is to study communication and its forms in new media. The term ‘new media’ can be used to describe an

emerging method of communication, and/or refer to media that has redefined our consumption of media.

The Distributed Real-Time Systems Research Group (DRTS)

The DRTS group is carrying out research in the area of distributed real-time systems and especially distributed real-time database systems and timeliness testing of event-triggered real-time systems. The objective of the DRTS is to study and solve the special synchronization, communication, and dynamic scheduling problems that appear in complex distributed real-time systems. In particular we study real-time database systems with soft, firm and hard deadlines, reactive mechanisms and event monitoring, as well as testability and software testing using model-based and mutation-based techniques developed in this area.

DRTS is involved in several funded research projects related to information fusion, testing and simulation. The group has a long tradition of studying issues related to software quality and non-functional requirements in real-time systems such as dependability, reliability and testability. In testing, we have expertise within the field of testing in general, model-based testing and especially mutation-based testing. Recent activities involve the investigation of how to use features from our real-time database prototype DeeDS in the infrastructure for supporting distributed information fusion systems. A Wireless Sensor Network testbed has also been built.

The Information Systems Research Group (IS)

The IS group is focused on development and use of IT systems for supplying information management in organisations. The group seeks to advance the theory and practice of business and information systems development. Both organisational and technical aspects are considered, and the goal is to achieve information systems of high quality and which fulfill the needs of their users. The group's research is organised according to the following areas:

- E-services: identification, development, use, and refinement of e-services for both private and public organisations. A user perspective is applied, e.g. concerning how e-service users can be included in the development process.
- Business modelling: business modelling practices, emphasizing effects in different contexts (such as business development and requirements engineering in systems development, planning and execution of modelling, and competence with modelling practitioners).

- E-health: a process-oriented perspective with the patient in focus gives research that aims to support both healthcare staff and patients, and how IT can be used to support healthcare processes.
- Information security: administrative information security and a process-oriented viewpoint. Furthermore, the trust aspect is included as well. Information security is successfully combined with e-health. Trust is successfully combined with e-health and e-services.
- Decision support systems and business intelligence: focuses on challenges regarding providing decision makers with relevant and timely information to enable high quality decisions. Decision making processes, information gathering and information management procedures and technical support systems are developed in concert so the design meets requirements of the decision makers and the organizational context.

The Interaction Lab (iLAB)

The Interaction Lab (iLab) is a relatively recent (January 2012) merger of the former Cognition & Interaction (COIN) Lab and the former Interactable Games & Media (InGaMe) Lab. The iLab is the largest research group in the IRC and constitutes about a third of it. The iLab has 3-4 main research areas, which are highly overlapping in terms of both research themes and staff involved: (1) cognitive systems & robotics, (2) human-machine interaction, (3) computer games, and (4) social interaction.

The research in cognitive systems & robotics developed from neural net-work and cognitive modelling research in the 1990s and has since 2005 been successful in attracting mainly European funding for a series of inter-disciplinary projects and networks in collaboration with neuroscientists, psychologists, roboticists, etc. Prominent research themes in recent years have been theories and models of embodied cognition, emotion and social (human-robot) interaction. The research in human-machine interaction has developed from, on the one hand, research on situated and distributed cognition, and more recently, on the other hand, research on visualization and cooperation in virtual environments. Recent projects, supported mainly by Swedish funding, include studies of communication in crises (together with the IS group), usability of dental care support systems (together with SAIL), and studies of decision-making/support in agriculture (together with SLU, the Swedish University of Agricultural Sciences).

The computer games research is mainly focused on so-called “serious games”, i.e. the use of computer game technology for purposes other than entertainment, in particular games for training and education, e.g. the use of gaming techniques in military training (a project in collaboration with the local Land Warfare Centre) or training of fire fighters (a project in collaboration with the Swedish Rescue Training Centre). Funding comes from a variety of sources, Swedish and European.

The research on social interaction is originally relatively fundamental in nature (addressing such issues as action recognition or the role of embodiment in social interaction), but has in recent years mainly been pursued in the context of technology projects, e.g. social interaction in and around computer games, cooperation in virtual environments, intention recognition in traffic, etc.

The Skövde Artificial Intelligence Lab (SAIL)

The SAIL group’s research is focused towards development of intelligent systems, i.e. systems that exhibit higher cognitive abilities normally associated with humans, e.g. reasoning, decision-making and learning. This breaks down into two main research directions. The first is representations and algorithms for knowledge systems, decision support and learning, and the second is visual analytics, specifically how user interactive visualisation can support analytical processes. The group has extensive experience in many of the main techniques for dealing with Big Data, e.g. data fusion and data integration, data mining, association rule learning, classification, supervised learning, cluster analysis, unsupervised learning, ensemble learning, genetic algorithms, neural networks and visualisation.

The other main research application area of SAIL, spanning the two research directions above, is within medical informatics. SAIL has more than 15 years of experience of collaboration with partners within this area, notably Chalmers University of Technology, University of Gothenburg, the Sahlgrenska Academy, and all major providers of public dental health care in Sweden. This research collaboration is unique in that it includes researchers within computer science, interaction design and odontology, as well as practitioners within the field. In contrast to the majority of the research in the field, SAIL’s research is focused on how to operationalize the data that is collected in daily clinical work in order to support evidence-based medicine, without losing the coupling between the people and work processes generating this evidence and the unique properties of the computer as a new design material. As a spin-off of the research, a company providing ICT solutions within dental health care and research has been formed.

The Software Systems Research Group (SSRG)

The mission of SSRG is to advance theory and practice in socio-technical issues in the use and development of software systems. Its remit encompasses methods, models and tools for all stages of the software systems life-cycle. It is dedicated to:

- Fostering innovative, industrially relevant socio-technical research in the software systems domain,
- Working with companies and public sector organisations to improve practice in the use and development of software systems,
- Educating the next generation of researchers and practitioners in advanced software technologies.

Its research is focused on: distributed, open source and inner source development processes; software development assets and asset interchange; open architectures and open standards. SSRG has an on-going collaboration with several internationally leading research groups in the area of Software Systems and Open Source, and members of the group are also well connected with a number of key stakeholders in the broader Open Source community. Further, research results from the group have also had an influence on EU and national IT-strategies and policy. Researchers in SSRG have significant experience from involvement as partner in high profile research projects, and from different leading roles and collaboration in several international and national research projects. Our experience includes project collaboration with academia, large international fortune 500-companies, as well as small companies and various other types of organisations (such as international and national Open Source associations).

A3.2 Personnel

Present a general analysis on staff related to personnel tables in section B1.1 (Max 1 page)

The centre has five (5) full professors, one (1) adjunct professor, three (3) associate professors, 18 assistant professors, five (5) post docs, seven (7) Ph.D. students, and three (3) lectures doing Ph.D. studies. Further, several additional persons with supplementary competences (e.g. technicians, lecturers, research assistants, administrative support staff) also contribute to research activities within the centre.

Overall, the eight full and associate professors devote the majority of their effort to research activities. Most research projects are initiated and

coordinated by one of these professors. However, junior researchers are also involved in early project discussions. This form of research apprenticeship has been established as an institutionalised practice, and involvement of assistant professors in early discussions with potential project partners concerning planning and design of research collaborations has been adopted as an effective way of working. In some cases, assistant professors also have leading roles within projects.

In essence, the full and associate professors spend the majority of their time on research activities. However, two of the full professors have other duties outside the centre (Dean for the Faculty Board for Informatics, Engineering and Natural Sciences, and pro-vice chancellor for the university). To expand the capacity for initiating and managing research projects within the centre, the university has taken a strategic decision to recruit three (3) full professors within Informatics. One of these new full professors was recruited and employed during 2012, whereas the other two were employed during first half of 2013. Hence, during the timeframe for the assessment, four full professors have been able to publish research results as an outcome of research activities within the centre.

Considering research efforts from assistant professors, it is noted that there is a significant variation concerning time spent for research activities between individuals. Some assistant professors have significant teaching (or other) commitments with limited time allocated for research. This implies additional logistic complexity, in particular when participating in collaborative research projects with external partners. This is a challenge for all actors and stakeholders involved, but with the new recruitments, the centre envisages an increased dynamic for initiating and establishing new innovative research projects within the field of Informatics.

A3.3 Infrastructure, facilities and funding:

Provide a description of the infrastructure of the UoA (not the general infrastructure of the university) that is used to do research (such as laboratories, specific ICT-support; infrastructure for fund raising, collaboration with society, etc.). (Max 3 pages)

A number of technical support infrastructures are used by researchers in different research projects. Concerning collaboration, we employ a variety of platforms and IT support tools depending on the context. In some cases, requirements from other (often industrial) partners impose restrictions on which infrastructure can be used. Some projects that develop software systems and other technical artefacts use dedicated infrastructures and platforms for

development and maintenance of developed solutions (e.g. SVN/GitHub are used in some projects for hosting and deploying software systems). We note that some research projects need to use and manage specific solutions and ICT infrastructures which are not provided via the general infrastructure of the University. For example, projects in the area of Open Systems have specific needs which are inherently incompatible with the general ICT infrastructure provided by the University and funding agencies.

IRC research activities have utilised the facilities and networks offered by the technology park (Gothia Science Park, GSP) which is tightly connected with the University of Skövde. GSP is a technology and research park with IT profile. It consists of activities, processes, environments and individuals. GSP is an environment created for growth and innovation with the support of IT and technology, and is for companies and organisations located within our environment as well as the surrounding business community. Development projects within collaborations between companies, academia and the community are essential for creating knowledge and competence development that strengthens the companies of the Skövde region, irrespective of industry.

GSP is an Open Arena for the sustainable development of knowledge and competence as well as new products, services and processes. The Arena is a neutral and strategic development partner for activities within and related to our IT profile. This open arena has contributed to networking and initial exploration of project ideas, and as such acted as a catalyst for initiated new collaborative research projects that involve companies. In 2009, Skövde Municipality and Gothia Science Park was recognised by the EU and awarded the European Enterprise Awards.

Some research projects need specific lab environments and demonstrators for conduction of research activities. For example, research activities undertaken in the area of distributed real-time systems use lab equipment consisting of a powerful workstation for simulations and a wireless sensor network. Similarly, research activities in cognitive/interactive systems have created two main lab environments for conduction of research studies; a car environment and a home environment, where different activities and behaviours can be studied with the aid of surveillance equipment. The lab is frequently used by students, researchers and external partners. Further, the iLab uses a ShapeHandPlus™ motion capture device for action recognition research. The combination of ShapeHand™ data glove and arm tracking ShapeTape™ allows the precise and reliable capture of the kinematics of fine-grained arm and hand movements. Researchers have access to a NAO humanoid, a bipedal robot capable of roughly human-like locomotion and rudimentary object manipulation, as well as an advanced six degree-of-freedom binocular and binaural iCub humanoid

robot head. Two additional NAO humanoids of the Next Gen type will be acquired during 2013. The lab also has 6-7 licenses of the Webots Pro robot simulation software (with premier support option). The lab also still has a couple of Khepera mobile robots as well as Lego robot kits, which are, however, no longer used much, except for occasional student projects or demos.

Researchers within the centre participate on a regular basis in events organised by funding agencies related to new opportunities for research funding and there is an on-going dialogue with representatives for international and national funding agencies. Further, some researchers are also invited and acting as reviewers of funding proposals and on-going projects at international and national levels on a regular basis. These activities provide valuable insights into a variety of different issues related to externally funded research projects, something which is of long-term value for the whole centre.

A4. Impact, engagement, and co-operation with society

In this section, the UoA describes its efforts to collaborate with society to ensure that research conducted has an impact on society. The section aims to provide the basis for a more holistic and situated evaluation of research impact than is possible from the cases (described in C).

A4.1. Collaboration with society in the UoA

Give an overview of the most promising current collaboration, including primary missions and goals. Describe how current collaboration affects the quality of research. Include evidence and specific details/examples adopted by the UoA rather than broad and vague statements. Do not repeat specific details already included in the case studies (section C). (Max 4 pages)

In light of IRCs mission (see A1.1), IRC researchers aim to publish research results in peer-reviewed scientific journals and conferences of high international standing. To achieve benefits of man and society, there is also an institutionalised effort amongst researchers to collaborate with and have an impact in specific areas of Informatics. A significant part of the research is conducted in collaboration with external partners, in both industry and the public sector. Conduction of applied research projects, which include involvement of practitioners representing specific organisations, is a means for achieving relevance to practice and a broader impact on society. Researchers within the centre acknowledge the importance of undertaking different types

of research projects, and over time research activities involve a mix of more fundamental research projects, and more applied research projects involving companies and other types of organisations.

Researchers within the centre have developed extensive networks of internationally and nationally recognised key players and organisations related to several focused areas in Informatics. Researchers have established strong informal links with researchers and practitioners representing a variety of different organisations and companies in the area. Efforts for collaboration and fund-raising are dynamic and often opportunities evolve through the established networks. All these contacts and roles are supplementary, and when considered together, constitute an extremely valuable network for long-term collaborations with society in the area.

Some of these networks are more formalised as they have received funding, whereas others are more long-term informal networks. Amongst international networks, IRC researchers have established and actively participated in research and research education networks in the areas of cognitive systems (e.g. euCognition, EUCogII, EUCogIII, financially supported by EU FP6, EU FP7) and open source (e.g. NOSS, Nordic Open Source Software Network, financially supported by NordForsk). Amongst other networks, IRC researchers have established and actively participated in research networks in different focused areas of Informatics, which significantly has contributed to establish a long-term relationship with other institutions and key stakeholders of relevance for the centre. These networks include:

- Open Source Sweden, an industry association for Swedish Open source companies.
- Open Forum Academy, a think tank with a broad aim to examine the paradigm shift towards openness in computing.
- SIG Security, a Swedish information security community for researchers and practitioners.
- Swedish Information Systems Academy, an association of Swedish universities with researchers in Information Systems.

Furthermore, researchers within the centre have on-going interactions and strong relationships with national, regional and local organisations (see also case descriptions in Part C). This networking provides an important contribution to different types of collaboration, which in some cases have developed to research. Researchers within the centre are involved in a number of on-going research and practice focused collaboration initiatives. These include involvement in:

- The EU project HELICOPTER in the area of ambient assisted living together with Skövde municipality.
- The EU project Quality of life for senior elders together with the Skövde municipality. This relates to a previously developed demonstrator (WeShare2012 --- demonstrator 2).
- Pre-studies in the Envolve project with local energy companies and equipment manufacturers. This work has led to funded energy-analysis collaboration with SP Technical Research Institute of 7 Sweden and the Secondary School Sötåsen (close to Skövde).
- An anti-online fraud training research project in collaboration with the Swedish Internet Infrastructure Foundation (stiftelsen .se).
- Collaboration with consultancy firms (ADMIT Systemer A/S, Visuera Integration AB and Actea consulting AB), has resulted in an EU project (EUREKA Eurostars), and an industrial Ph.D. student.
- There are extensive network of collaborations with national and regional health care organisations (e.g. specialist care units at hospitals, primary health care centers, municipalities and health regions).
- Collaboration with New Tools of Health (HNV) in Linköping is being launched, a non-profit organization that provides a large network of contacts with healthcare organizations, industry, and society.
- Collaboration with the Swedish Rural Economy and Agricultural Society in in Skaraborg in the area of farmers' decision-making and decision support systems.
- Crisis management training workshops have been organised since 2006 in collaboration with 18 local municipalities in order to develop their information management capabilities for crisis situations. This involves an external crisis management training consultant.
- Collaboration with the KIVOS network (an Open Source network established by municipalities in the west of Sweden).
- Collaboration with the Association for municipalities in Skaraborg (involving 15 local municipalities close to Skövde).
- Collaboration with Saab Aeronautics in Linköping concerning platform independent testing.
- Several different collaboration activities (some of which are elaborated in case 1 in Part C) with different companies within the Saab AB group.
- Collaboration with the Swedish games industry as well as some of the start-up companies started by former students from the University of Skövde situated in GSP.
- Collaboration with Volvo Cars and the Viktoria Institute on human-car interaction.

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A4.2 External collaborations and contributions that support the research within the UoA

Describe supporting key external research collaborations and contributions from actors outside the UoA. Describe facilities and advanced equipment at partner organizations that is used by the UoA. (Max 1 page)

Most research activities conducted within the centre do not need specific advanced equipment from external partner organisations. Most software systems and other digital artefacts developed as part of research projects are deployed on externally hosted platforms. However, it should be noted that the conduction of several research projects need specific software development environments and tools, and there is a need for storage space and maintenance of digital artefacts developed during research activities that goes beyond what is centrally offered by the university. In some cases, such requirements from research projects may impose special handling and solutions.

Some research projects use advanced equipment at partner organisations. For example, as part of an on-going collaboration on human-car interaction with Volvo Cars and the Viktoria Institute, the involved researchers within the centre have been using Volvo Cars' car simulator in Gothenburg for experimental user studies since 2012.

A4.3 Innovation activities

The UoA describes the most significant innovations during 2007-2012 making an impact (i.e., a change) on society (Max 3 pages). Examples of innovation are products, designs, processes, methods, etc. The innovations can be realized within the university or by a partner and listed at the end (not included in the three pages) and should not be more than 15.

In addition to innovations activities and impact from these (see case descriptions in Part C), researchers within the centre have contributed to significant innovation which has had an impact on society. Some illustrative examples are presented below.

First, a number of software packages have been developed as an outcome of research conducted in the area of information fusion and deployed as Open Source Software packages. These are provided via the SourceForge platform: DESIRER: Development Environment for Situation REcognition Research (under the LGPLv3 license) and SWARD: System for Weapon Allocation Research and Development (under the BSD license). It should be noted that the choice of software licenses for both these software packages are provided under

conditions which allow incorporation in proprietary licensed (as well as Open Source licensed) software systems.

Second, as part of research activities conducted within the area of information fusion, researchers within the centre have been actively involved in the development of algorithms which have contributed to two novel products offered by Saab AB in the area of maritime surveillance. For example, see SAAB's intelligent behaviour detector IBD:

<http://www.saabgroup.com/en/Civil-security/Maritime-Transportation-and-Port-Security/Coastal-Surveillance-Solutions/Surveillance-Radars/IBDIntelligentBehaviourDetector/>

Third, another example is the SOMWeb system for distributed collaboration within medicine aiming at bridging the gap between practitioners and researchers. SOMWeb is based on research on a general framework combining research from interaction design (end-user development) with research on web-based knowledge systems (semantic web), a framework later reused in Gerioweb, a novel system for gerodontology. Gerioweb is a product of Spectacon, a company providing ICT solutions based on research results from the UoA. So far, Gerioweb has been sold to 15 regional organizations within public dental care in Sweden, including the two largest, Region Västra Götaland and Stockholm County Council.

Fourth, the ideas put forward in the demonstrator developed in the VFI project (Future Information Systems in Healthcare) provides contributions to a report commissioned by the Swedish government, and as such constitutes one important basis for policy decisions in this area. The report focused on the usability and usefulness of e-Health systems in Swedish healthcare and was carried out in collaboration with the trade union organisations concerned, e.g. the Swedish Association for Health Professionals. Information (in Swedish) about the content of the report can be found at:

<https://www.vardforbundet.se/Agenda/Pressrum/Pressmeddelanden/Utmaningar-i-var-d-och-omsorg-kraver-stora-satsningar-pa-eHalsa/>.

The report has also recently been commented on in the Swedish magazine Computer Sweden (in Swedish):

<http://computersweden.idg.se/2.2683/1.512445/personalen-sagar-var-dens-it-system>.

Fifth, as an outcome of the TOFFEE project a computerized product catalogue with associated e-services was developed. This catalogue resulted in a product which a company (Visuera) currently offers as a general application

(<http://visuera.com/e-tjaenster.aspx>). The product catalogue is a tool for efficient procurement and is currently used by Region Västra Götaland.

Finally, one recent innovative development to which researchers within the centre have contributed is a novel approach for supporting software architects and resulting from this is the Open Source licensed ArCon project which is in the process of becoming part of the release train in the Eclipse platform (currently it is provided as an Eclipse labs project). The tool developed in this project is currently used in a number of different commercial contexts and it is becoming part of the tool offerings from the Eclipse IWG PolarSys (www.polarsys.org). From this, researchers within the centre have become members of the Eclipse foundation and PolarSys.

A5. Self-assessment and future development

In this section the UoA should provide a self-assessment of its present opportunities for improvements. What does the UoA aim to achieve, e.g. in terms of activities within the UoA, external networking, interdisciplinary activities, joint publications and funding?

A5.1 Self-assessment of the UoA

Based on the quantitative data (part B) and qualitative assessment above, list strengths, weaknesses, opportunities and challenges (threats) of the UoA and of the research conducted. Strengths and weaknesses refer to properties of the UoA, whereas opportunities and challenges normally refer to external factors. Propose actions that would improve the quality of the research. Consider both purely academic factors and factors related to cooperation with external partners.

The UoA must grade, on a scale 1-8, and motivate the premises and ability to

- *recruit qualified staff and PhD students,*
- *attract external research funding,*
- *position the UoA internationally.*

Here, 1 means poor and 8 means excellent. Apply a long-term perspective of the strategic planning of the UoA and what priorities that will be made regarding future research (max 10 pages).

A5.1.1 SWOT analysis

Strengths

The IRC's research and results in several areas have received international recognition. The quality and focus of the research is attractive for partners in academia, industry and society, at both international and national levels. Several research projects are conducted in close collaboration with industry and society, which contributes to balancing practical (shorter-term) relevance with the need for (longer-term) theoretical advancements of specific aspects of Informatics. Long-term research efforts address relevant problems and many of the IRC's researchers/groups have established strong local, national and/or international networks.

IRC researchers have established long-lasting relationships with external organisations, and often research projects are initiated with partners that previously have experienced successful research collaboration with researchers. Many of the researchers are passionate about their research, and regularly publish results in internationally recognised (peer-reviewed) journals and conferences. In certain areas of Informatics, there are strong international networks.

Weaknesses

Many IRC researchers need to become more effective in their dissemination and more focused on scientific impact. There is a need to increase the focus on publication of research results in international (peer-reviewed) high-quality journals. Dissemination must be an inherent part of all (long and short term) research activities – at the level of research projects, research groups, and individual researchers.

There is a need to attract more external funding and increase the overall volume of research in the IRC. Many researchers in the centre have limited research activity, partly as a consequence of heavy teaching commitments and other duties. While there is extensive international collaboration in some areas, there is a lack of such collaborations in others. There is limited support for specific IT-infrastructure, platforms, and maintenance of research data that is needed for research in specific areas of Informatics, which constrains some research activities, for example when specific needs are not in congruence with what is offered and supported by the university's general IT-infrastructure.

Opportunities

Many IRC researchers are well connected, with extensive networks at local, national, and international levels providing opportunities for new innovative collaborations and external funding. A thorough understanding of the field of practice and the extensive body of knowledge in the focus area for specific research initiatives create opportunities for establishing research questions and projects that are considered relevant by potential partners in research projects. Although there is already much collaboration between groups, there is still a significant unexplored potential for collaboration between researchers and research groups. Extensive and systematic efforts for attracting external funding create opportunities for extending research efforts and activities.

Some researchers within the centre envisage unexplored potential for increased publishing opportunities by means of using results and data from previous projects, whereas other researchers consider such efforts to constitute part of an overarching planned publishing strategy. Increased visibility of research activities and research results from the IRC may be promoted by use of effective communication. The societal significance for the competences related to some areas of focus for the centre is likely to increase over time, which may contribute to increased opportunities for new innovative research projects.

Challenges

Research projects in some cases suffer from insufficient personnel resources and therefore need to recruit new members relatively quickly when research proposals with external funding are accepted. IRC researchers need to attract external funding and at the same time manage the challenge for staffing accepted proposals/projects with motivated and available researchers that have the appropriate competences for the project activities at hand. This is also a logistic challenge, especially when funding is limited and does not fully cover new recruitments. Attracting qualified and skilled candidates for upcoming projects and available positions from internal study programmes is a challenge, especially given that the focus in study programmes at M.Sc. and B.Sc. levels has become less theoretically focused in recent years, as a consequence of addressing shorter-term needs for more applied study programmes from industry. To maintain a solid theoretical basis at M.Sc. and B.Sc. levels may become a challenge, but at the same time be a prerequisite for the centre to be able to attract theoretically motivated students from own study programmes into research studies.

IRC research activities need to balance theoretically focused long-term research with more applied research projects that often involve industrial partners. External funding from the Knowledge Foundation for the industrial Ph.D. study programme, ApplyIT, is absolutely crucial for informatics graduate education at this point, whereas attracting other external research funding for Ph.D. students in more theoretically focused projects is a challenge. There is a (very) limited risk for uninformed policy decisions and other external circumstances related to a specific focus area in the centre (e.g. Open Systems) that may negatively impact on opportunities for attracting external research funding.

A5.1.2 “Grading” 1-8

The centre grades itself, on a scale 1-8, and motivates the premises and ability to:

- *Recruit qualified staff and Ph.D. students: 6*
- *Attract external research funding: 6*
- *Position the UoA internationally: 6*

Here, 1 means poor and 8 means excellent.

Recruit qualified staff and Ph.D. student: 6

The self-assessment “6” for this factor is motivated as follows:

The ability to recruit qualified staff stems from international and national networks that have enabled the centre to recruit qualified postdocs and senior researchers over the years. During 2011-2012, the centre has successfully recruited three⁶ new full professors (of which one was employed in 2012, and the other two start in 2013).

For many years, industrial Ph.D. students have provided important contributions to the centre, and we envisage that their involvement will continue to be essential for in high-profile research projects and activities. Besides ensuring industrial relevance, there are several examples of research projects in which industrial Ph.D. students have contributed to scientific outcomes of high international standing.

Over the years, we have experienced an increasing reluctance amongst many funding agencies to financially support Ph.D. student activities as part of

⁶ Two of the new full professors were internationally recruited.

funded research projects. This has resulted in fewer opportunities for attracting external funding for Ph.D. student positions as part of research projects, which contributes to the somewhat lower number of active Ph.D. students within the centre. For this reason, the IRC has actively promoted actions for establishing stronger ties with industry by means of recruiting industrial Ph.D. students to the centre. One such action is the establishment of the industrial Ph.D. study programme ApplyIT, funded by the Knowledge Foundation.

Further, there are also examples of major contributions to scientific outcomes developed by internally recruited Ph.D. students that have a background from B.Sc. and M.Sc. level study programmes in Informatics at the University of Skövde. Given that the pool of theoretically motivated students and B.Sc. and M.Sc. levels are limited, it is crucial for the long-term development of the IRC and its associated research education in Informatics that such students are offered a stimulating path from B.Sc. study programmes (via M.Sc. level) to Ph.D. level education within the field of Informatics.

Attract external research funding: 6

The self-assessment “6” for this factor is motivated as follows:

Some IRC researchers regularly receive invitations to join proposals for collaborative research with internationally recognised academic and industrial partners. IRC researchers are active in seeking external funding for research and the outcome of such efforts have been relatively successful during the period for the assessment. Opportunities for continuing to attract external research funding are fairly high. Certain areas of Informatics have focused their efforts for seeking external funding towards the EU, whereas others have had stronger focus on seeking national funding. Efforts for attracting funding have tried to combine an appropriate mix of seeking funding for smaller and larger research projects, and also balancing proposals for more applied and theoretically focused research projects.

Position the IRC internationally: 6

The self-assessment “6” for this factor is motivated as follows:

Several IRC researchers/groups have established strong links with internationally recognised academic and industrial research partners. In several areas of a number of research projects have been conducted with international partners of high standing. IRC research projects have involved collaboration with highly skilled individuals representing different types of partners,

including: research institutes, companies, public sector organisations, policy makers etc.

Established networks with internationally recognised academic institutions, industry and public sector organisations, promote good access and opportunities for collaboration, both internationally and nationally, with other researchers, practitioners and policy makers. National and international positioning of the centre is still to be developed further.

A5.1.3 Strategic planning of the IRC

Apply a long-term perspective of the strategic planning of the UoA and what priorities that will be made regarding future research

Amongst a number of identified issues for long-term improvement, we wish to highlight the following priorities regarding future research:

- Increased focus on publication of research results in internationally recognised high-quality journals.
- The need to maintain and further develop already established strong international and national networks and to actively seek new partners of high international standing for future research collaboration.
- The need to increase the number of skilled researchers involved in the process of seeking external research funding from different types of recognised funding agencies.
- Improved mentorship for junior researchers in order to promote involvement in high-quality research and applications for external research funding.

Part B: Quantitative data of the UoA

In this part of the evaluation package questions and tables are presented in 3 sections which contain quantifiable information about the UoA in support of the statements made in Part A above.

B1: Research environment and infrastructure

B2: Research output

B3: Impact, engagement and co-operation with society

B1. Research environment and infrastructure

B1.1 Staff statistics

Provide information of the number of individuals and full time equivalents (FTE) of staffs' research activity. The 'M' columns show values for men and 'W' for women. The number of individuals refers to Dec 31st each year, whereas FTE is integrated over the whole year. FTE is only presented for 2011 and 2012.

Table B1.1.1. Number of and full time equivalents of permanent research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Professor	5	1	4	1	4	1	4	1	4	1	3	2
FTE									3	0.5	1.8	1
Assoc. prof. (Lektor and docent)	2	1	2		2	1	2	1	2	1	2	1
FTE									1.5	1	1.6	0.5
Assist. prof. (Lektor, forskare)	7		8	2	8	4	9	3	9	5	12	6
FTE									4	1.1	4,6	1.9
Lecturer (Adjunkt)			1	1	2		3	1	3	1	4	
FTE									1.7	0.4	2.2	
Total Individuals	14	2	15	4	16	6	18	6	18	8	21	9
Total FTE									10	3	10	3.4

¹ Professor denotes persons employed as full professors. Associate professor denotes staff qualified to act as principal advisor for PhD students (docent appointment or similar). Assistant professors denote the rest of staff with a PhD.

Table B1.1.2. Number of and full time equivalents of temporary research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W

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Guest profs	2		2		2		1					
FTE												
Adjunct profs			2		1		1		1		1	
FTE									0.1		0.1	
Assistant professor												
FTE												
Post-Docs and research assistants	3	1	5	2	5	1	7		9	2	5	
FTE									4.7	0.8	3.1	
PhD students ¹	14	10	12	10	12	10	9	7	7	3	8	4
FTE									3.8	1.9	5.3	2.4
Total individuals	19	11	21	12	19	11	18	7	17	5	14	4
Total FTE									8.6	2.7	8.5	2.4

¹ All temporary employed admitted to PhD studies

Table B1.1.3. Other staff supporting research in UoA												
Year	2007		2008		2009		2010		2011		2012	
Staff	M	W	M	W	M	W	M	W	M	W	M	W
Research assistant/ Technician	3	1					2		2			
FTE									1		0.3	
Administrator												
FTE												
Total individuals	3	1					2		2			
Total FTE									1		0.3	

¹ Fixed term and visiting research staff. Staff is included in the research output as well as in the bibliometric analysis.

B1.2 Research funding

Sources of research funding and amounts given to the UoA annually during 2007-2012.

Table B.1.2.1. External funding (spent money in t SEK)						
	2007	2008	2009	2010	2011	2012
Research Councils (VR, FAS, Formas etc.)		12	227	168	385	382
Swedish Foundations (e.g. Wallenberg, SSF, Vinnova, RJ, KK, Swedish Energy Agency etc.)	7446	8027	7095	10152	8002	9948
EU	3033	3725	6264	4254	4029	3256

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Other public bodies (e.g. county councils, municipalities, etc.)	2069	2498	4252	2891	5222	3157
Direct external funding from industry.		20	474	226	773	911
University	2464	935	1216	751	1051	1115
Others (please specify)						
TOTAL	15012	15217	19528	18442	19462	18769

Table B.1.2.2. Total Research Funding t SEK

	2007	2008	2009	2010	2011	2012
Total external funding (from table B.1.2.1.)	15012	15127	19528	18442	19462	18769
Faculty funding (governmental funding)	14201	12621	11398	13667	10514	10090
Percentage external funding	51	55	63	57	65	65
Research as competence development	8204	9680	17519	1751	3029	3098
TOTAL	37417	37518	48445	33860	33005	31957

B1.3 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during **2011-2012** by permanent research staff.

Table B1.3.1 International networks and collaborations

Number of collaboration institutions ¹	50+
Number of research visits abroad (1 week to 1 month duration)	5+
Number of research visits abroad (of at least 1 month duration)	5+
Number of visiting researchers (1 week to 1 month duration)	5+
Number of visiting researchers (of at least 1 month duration)	5+
Number of funded international research consortia projects	10+

¹ Research collaborations given here are limited to those with joint research grants in excess of 100kSEK/year and/or joint publications with the UoA.

B1.3.3 Other major international activities according to the tradition of the research field¹	Total No.
Expert contributions to EU-policy as part of the Digital Agenda Europe (specifically for Action 23), and to the UK Government IT-strategy for Open Standards.	1

¹ Please specify: scientific expeditions, field work etc. and list below including duration
A maximum of five examples in total may be provided.

B1.4. Participation in scientific community

UoAs activities undertaken during 2007-2012 that illustrate high quality leadership interactions with their scientific peers.

B1.4.1 Participation in academic community	Number
Plenary or keynote talk at international conferences	5+
Assignment as expert in research councils and foundations	
Assignment as expert evaluator for position as professor, associate professor (docent) and lecturer	20+
Assignment as opponent for PhD thesis	10+
Assignment as member of examination board for PhD thesis	20+
Assignment as editor or member of editorial board for journal	5+
Assignment as reviewer for international journal	100+
Member of national scientific councils	5+
Member of international scientific councils	5+
Chair of program committee (international conferences)	10+
Member of program committee (international conferences)	100+

B1.5 Recruitments

Number of recruited research staff, men (M) and women (W) during 2007-2012.

B1.5.1 Recruitments	Number	
	M	W
Recruitments with doctoral degree from another Swedish university	5	6
Recruitments with a doctoral degree from outside Sweden	5	
Recruitment with doctoral degree from own university		
TOTAL	10	6

B2. Research Output

B2.1 Promotions and degrees

This section quantifies the development of scientific staff during 2007 to 2012 distinguishing men (M) and women (W).

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B2.1.1. Doctoral degrees awarded and promotion of researchers												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
No. Doctoral degrees	3	1	5	3	3	3	3	1	4	3	1	
No. Docent promotions	1			2	1	1	1					
No. Professor promotions	2	1										
TOTAL	6	2	5	5	4	4	4	1	4	3	1	

B2.2 Publications

Publications and other research output achieved during 2005-2012 to provide the publication profile of the UoA.

Table B2.2.1: Total number of scientific publications produced by the UoA. Please specify citation index in each publication list.										
Publication types	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Article in journal, peer reviewed	10	10	6	10	10	7	14	4	71	8.9
Article in journal, not peer reviewed		2			2	1		1	6	0.8
Article in journal, book review										0.0
Article in journal, review					1		1		2	0.3
Book				1					1	0.1
Edited book	1		1	2		1	1		6	0.8
Chapter in book	3	1	9	9	20	4	2	14	62	7.8

Conference paper (peer reviewed)	47	40	73	57	56	38	30	33	374	46.8
Conference paper (not peer reviewed)	6	21		2	1				30	3.8
Thesis, doctoral	1		3	5	5	5	4	1	24	3.0
Thesis, licentiate ¹	1	2	1	2	2		3	2	13	1.6
Thesis, master	-	-	-	-	-	-	-	-	-	-
Report	4	10	8	4	2		2	2	32	4.0
Other scientific publication	-	-	-	-	-	-	-	-	-	-

¹ Licentiate is a Swedish and Finnish academic degree on graduate level corresponding to circa half a Swedish PhD.

Table B2.2.2. Aggregate publication information

	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Total number of publications in DiVA	73	86	101	92	99	56	57	57	621	77.6
Number of publications in Web of Science	16	34	37	25	30	13	11	5	171	21.4

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Number of publications in Web of Science, author fractiona-lized	11.5	24.6	24.6	15.9	21.5	10.0	7.9	2.8	118.9	14.9
Web of Science visibility (percent of publications included)	22%	40%	37%	27%	30%	23%	19%	9%	28%	-
Scopus visibility (percent of publications included)	30%	36%	47%	50%	37%	55%	32%	39%	41%	-
Journals' field normalized impact	1.1	1.38	1.29	0.94	1.16	0.92	0.64	-	1.09	-
Journal Impact Factor	0.8	1.54	0.67	1.9	2.05	1.43	0.89	-	1.37	-
Norwegian score	34.6	37	50.7	49.6	64.3	38.1	32.9	40.5	347.7	43.5
Norwegian score fractiona-lized	29.3	27.1	34.4	33.1	48.3	31.5	23.6	28.3	255.5	31.9
Publica-tions in level 1 journal – Norwegian list	8	6	4	9	7	6	11	3	54	6.8

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Publications in level 2 journal – Norwegian list	1	2	1	1	4	1	1	2	13	1.6
Publications in level 1 conference – Norwegian list	23	31	48	40	37	31	22	25	257	32.1
Publications in level 2 conference – Norwegian list	5					2			7	0.9
Publications in level 1 book publishers	1		2	9	20	2	2	14	50	6.3
Publications in level 2 book publishers			3			1			4	0.5

Table B2.2.3. Citation indicators

	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Total number of citations	172	94	103	59	67	11	2	-	508
Number of citations, author fractionalized	140.3	43.0	53.1	44.8	46.2	7.8	1.1	-	336.3

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Citations per publication	10.8	2.8	2.8	2.4	2.2	0.8	0.2	-	3.1
Share of publications not cited	63%	50%	54%	48%	43%	54%	82%	-	53%
Average field normalized citation rate	1.5	0.52	2.32	0.79	0.97	0.27	0.37	-	0.89
Share of publications among the 10 percent most cited in the field	29%	0%	33%	0%	0%	0%	0%	-	7%
Share of publications among the 25 percent most cited in the field	43%	25%	100%	0%	43%	0%	0%	-	29%

Table B2.2.4. Authorship

	2005	2006	2007	2008	2009	2010	2011	2012	Total
Average authors per publication	2.6	3	3.1	3.2	3	2.8	3.6	3.2	3.0
Average countries per publication	1.1	1.2	1	1.1	1.1	1.1	1.2	1.2	1.1

Table B2.2.5. Role of key scholars

	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average

Share of publications by 3 most active authors	33%	35%	35%	29%	35%	45%	40%	30%	35%
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Table B2.2.6. Productivity

	2007	2008	2009	2010	2011	2012	Total	Annual average
Number of publications in relation to total funding (MSEK).	2.70	2.45	2.04	1.65	1.73	1.78	2.08	2.06
Number of publications in relation to FTEs					2.35	2.35	2.35	2.35
Number of citations in relation to FTEs					0.08	0.00	0.04	0.04

B2.3 Innovation output

As well as engaging with society through contract research or education, researchers today sometimes patent their findings, commercializing these through multiple routes. Researchers also form companies either based on patents, or other forms of intellectual property e.g. materials, software or experience. These activities, often referred to as ‘innovation activities’, are listed in the tables below for the years 2007-2012.

B2.3.1. Patents¹

Patent number ²	Short description	Person(s) involved at UoA	Date of registration

¹ Data should match that held in DiVA.

² Awarded patents only, not patent applications.

B2.3.2. Founded companies¹

Company name	Founder(s) from the UoA	Company type	Date of formation	Current status
Spectacon (org. no.	Göran falkman	Producer of ICT solutions	2009-09-30	Has recently signed contracts with all major organizations within public dental care in Sweden. Is

969744-9917)		within medicine and healthcare		involved in development of the successor/replacement of the T4 practice management software (http://www3.carestreamdental.com)
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¹ Included eligible companies must be a direct result of the university's research activities and have, or have had, an annual income in excess of 100 kSEK.

B3. Impact, engagement and co-operation in research with society

This section presents activities related to co-operation in research with society and the impact of such activities. It includes the unit's general approach to enable impact and engagement from its research, and also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B3.1 PhD degrees

The number of doctoral degrees (PhD, etc.) earned within the UoA during 2007-2012 when the awardee has been externally employed. Number of men ('M') and number of women ('W') are recorded per year.

Table B3.1.1. Doctoral degrees awarded to students externally employed												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
Number of doctoral degrees					1				1			

B3.2 Major research related co-operation with society

Activities regarding research related co-operation with society should be entered into one of three categories in the table below: Table 3.2.1 lists mobility between academia and non-academic society, such as exchanged lectures with external (non-academic) organisations, the engagement of adjunct professors, and externally financed PhD students in collaborative research projects with partners from industry or other organisations in society; Table 3.2.2 includes the number of publications co-authored with individuals outside of academic institutions, and popular publications aiming at the general public; Table 3.2.3 counts the number of external partners of the UoA separated between SME, large enterprises, and non-industrial partners; Table 3.2.4 summarizes the amount of *in kind* funding from industry and non-industrial organisations in society.

Table 3.2.1: Mobility between academy and society						
	2007	2008	2009	2010	2011	2012
No. of collaborative doctoral students ¹	4+	4+	4+	5+	4+	3+
No. of temporary research positions outside university ²					1	
No. of adjunct researchers	2+	2+	2+	2+	2+	2+

¹Number of doctoral students in the UoA who are financed by non-academic external partners. Note that this does not mean doctoral students who are financed by any non-academic funding body, but students who are financed by external partners to the UoA (e.g. industry or public sector organisations).

²Permanent UoA personnel who migrate from the university to non-academic society

Part C: Case descriptions

C.1. Impact cases

The number of cases required in each submission is two (max.). The case should have been carried out during the period January 1st 2007 to December 31st 2012. Each case must provide details not only of the academic impact e.g. publications in highly ranked journals, but also describe the impact of the excellent research on society.

Table C1.1.1 Template for impact cases

Long-term collaboration with Saab – from a final year project to a research direction

In 1994 an exchange student in Skövde made his master level project with Ericsson Microwave Systems. The project analysed the applicability of various algorithms to oil spill detection using Doppler radar data. This project was the starting point for a long term relation between Ericsson Microwave Systems and the University of Skövde. The collaboration continued with a project funded by the Swedish Ministry of Education (300 000 SEK) and another project funded by OKs Environmental Fund (175 000 SEK) on the same topic, i.e., Oil spill detection from radar imagery using artificial neural networks. This collaboration also resulted in a number of publications (some with researchers at the company – see Athley below).

Ziemke (1995) Recurrent Artificial Neural Networks for the Detection of Oil Spills from Doppler Radar Imagery. In Keating (ed.) Neural Computing Research and Applications III - Proceedings of the Fifth Irish Neural Network Conference, St. Patrick's College, Maynooth, Ireland.

Ziemke & Athley (1995) Oil Spill Detection from Doppler Radar Imagery Artificial Neural Networks. In Bulsari & Kallio (1995) Engineering Applications of Neural Networks - Proceedings of the International Conference EANN '95. Otaniemi/Helsinki, Finland: Finnish Artificial Intelligence Society.

Ziemke & Athley (1995) Connectionist Models for the Detection of Oil Spills from Doppler Radar Imagery. In Niklasson & Boden (eds.) Current Trends in Connectionism - Proceedings of the Swedish Conference on Connectionism - 1995. Hillsdale, NJ: Lawrence Erlbaum.

Ziemke (1996). Radar image segmentation using recurrent artificial neural networks. Pattern Recognition Letters, 17(4), 319-334.

Ziemke (1996) Radar Image Segmentation using Second-Order Recurrent Networks. In Bulsari, Kallio & Tsapinos (eds.) Solving Engineering Problems with Neural Networks - Proceedings of the International Conference on Engineering Applications of Neural Networks. Turku, Finland: Systems Engineering Association.

Ziemke (1997). Radar image segmentation using self-adapting recurrent networks. International Journal of Neural Systems, 8 (1), 47-54.

Ziemke, Boden & Niklasson (1997). Oil Spill Detection: A Case Study of Recurrent Artificial Neural Networks. In: Browne, A.J. (ed.) Neural Network Analysis, Architectures and Applications. Bristol, UK: IOP Publishing.

In 1999 Ericsson decided to establish a local office in Skövde, to make it easier to hire qualified personnel. The collaboration between their researchers at the university and Ericsson increased, and many smaller projects (mainly student projects) were conducted. A software competition for students was also launched in 2001 (see facsimile from the local newspaper on January 25th below).



Then in 2004 Ericsson Microwave Systems, University of Skövde and Chalmers University of Technology entered into a research project on flying sensors for ground surveillance (600 000 SEK to University of Skövde), funded within the Swedish National Avionics Research Program (NFFP3+), by the Swedish Governmental Agency for Innovation Systems. This project resulted in a pre-study on the need for research on information fusion, particularly information fusion for increased situation awareness. The project report¹ identified that there had been extensive research in object detection, alignment, identification and tracking, but there were a need for research on the identification of relations between objects and contextual information (e.g., geographical information or weather condition). This level of abstraction was in the literature named *situation awareness*. This level, in combination with future

¹ <http://urn.kb.se/resolve?urn=urn:nbn:se:his:diva-8195>

predictions based on the current situation, was regarded by Ericsson as very interesting to research in order to develop decision support for command and control systems. At this time the company intended to broaden its product portfolio with decision support capability, to complement its excellent track record on radar systems.

Together with Ericsson and fourteen other companies, the university formulated a research application within the area of information fusion for decision support. The university applied for 36 MSEK from the Knowledge Foundation (a national funding agency, supporting research collaboration between academia and industry) for a large research program on information fusion. Ericsson's involvement in the program was quite extensive and contributed with almost half of the industrial co-funding of the program, which was in the region of 55 MSEK in total – with an additional 29 MSEK from the University of Skövde. Ericsson and Skövde formed a project group on situation awareness, consisting of three senior researchers from Ericsson (of which two later became adjunct professors) and two industrial PhD-students (employed by Ericsson). The university personnel consisted of two professors, one associate professor and three PhD-students. The group identified five PhD projects of high relevance for Ericsson. In 2006 Ericsson sold Ericsson Microwave Systems (which later became SAAB Electronic Defence Systems) to the defence and security company SAAB. This meant that the research group was approached by several other researchers from SAAB who had an interest in the area. One additional PhD from another SAAB division (the one that now is called Security and Defence Solutions) was connected to the group. During the duration of the research project 2005-2011 the group published extensively within the area of information fusion, and in the main conference on the subject in particular, totaling about 50 papers in the area of information fusion (a subset presented below).

- Brax, C., Karlsson, A., Andler, S. F., Johansson, R. & Niklasson, L. (2010). Evaluating Precise and Imprecise State-Based Anomaly Detectors for Maritime Surveillance. In: Proceedings of the 13th International Conference on Information Fusion. IEEE conference proceedings.
- Brax, C., Niklasson, L. & Laxhammar, R. (2009). An ensemble approach for increased anomaly detection performance in video surveillance data. In: Proceedings of the 12th International Conference on Information Fusion (FUSION 2009). (pp. 694-701). IEEE.
- Brax, C., Niklasson, L. & Smedberg, M. (2008). Finding behavioural anomalies in public areas using video surveillance data. In: Proceedings of the 11th International Conference on Information Fusion (pp. 1655-1662). IEEE conference proceedings.
- Dahlbom, A. & Niklasson, L. (2007). Trajectory Clustering for Coastal Surveillance. In: 10th International Conference on Information Fusion (FUSION 2007), (pp. 1-8). IEEE Press.
- Dahlbom, A., Niklasson, L. & Falkman, G. (2010). Evolving Petri Nets for Situation Recognition. In: Hamid R. Arabnia, Ray R. Hashemi, Ashu M. G. Solo (Ed.), GEM 2010: Proceedings of the 2010 International Conference on Genetic and

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- Evolutionary Methods. (pp. 29-35). CSREA Press.
- Gustavsson, P. M., Hieb, M. R., Moore, P., Eriksson, P. & Niklasson, L. (2010). Operations Intent and Effects Model. *JDMS: Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*, 8(1), 37-59.
- Johansson, F. & Falkman, G. (2008). A Bayesian network approach to threat evaluation with application to an air defense scenario. In: *Proceedings of the 11th International Conference on Information Fusion*. (pp. 1352-1358). IEEE.
- Johansson, F. & Falkman, G. (2010). Real-time Allocation of Defensive Resources to Rockets, Artillery, and Mortars. In: *FUSION 2010: 13th international Conference on Information Fusion*, 26-29 July 2010, EICC, Edinburgh, UK. IEEE conference proceedings.
- Johansson, F. & Falkman, G. (2010). SWARD: System for Weapon Allocation Research & Development. In: *FUSION 2010: 13th international Conference on Information Fusion*, IEEE conference proceedings.
- Johansson, F. & Falkman, G. (2011). Real-time Allocation of Firing Units To Hostile Targets. *Journal of Advances in Information Fusion*, 6(2), 187-199.
- Laxhammar, R. & Falkman, G. (2011). Sequential Conformal Anomaly Detection in Trajectories based on Hausdorff Distance. In: *Proceedings of the 14th International Conference on Information Fusion (FUSION 2011)*. (pp. 153-160). IEEE Computer Society.
- Laxhammar, R., Falkman, G. & Sviestins, E. (2009). Anomaly detection in sea traffic - a comparison of the Gaussian Mixture Model and the Kernel Density Estimator. In: *Proceedings of the 12th International Conference on Information Fusion*. (pp. 756-763). ISIF.
- Riveiro, M. & Falkman, G. (2010). Supporting the analytical reasoning process in maritime anomaly detection: evaluation and experimental design. In: *Proceedings 2010 14th International Conference Information Visualisation: IV 2010* (pp. 170-178). IEEE Computer Society.
- Riveiro, M., Falkman, G. & Ziemke, T. (2008). Improving maritime anomaly detection and situation awareness through interactive visualization. In: *Proceedings of the 11th International Conference on Information Fusion (FUSION 2008)*. (pp. 47-54). IEEE Press.
- Riveiro, M., Falkman, G. & Ziemke, T. (2008). Visual Analytics for the Detection of Anomalous Maritime Behavior. In: *Proceedings of the 12th IEEE International Conference on Information Visualisation (IV '08)* (pp. 273-279). IEEE Computer Society.

In addition to this the five original PhD-students got their PhD diploma, and the PhD-student who joined later got his licentiate diploma. Two of the simulation environments² generated during the project were made publically available. The work

² DESIRER: Development Environemnt for Situation REcognition Research,
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of two of the industrial PhD-students also became key components in two products developed by SAAB (for at presentation of one of these see <http://www.saabgroup.com/en/Civil-security/Maritime-Transportation-and-Port-Security/Traffic-Management-Solutions/IBD-Anomally-Behavior-Detector/Features/>). This means that the research had a positive impact on the product portfolio of SAAB.

In 2010 another project³ was applied for and funded within the Swedish National Avionics Research Program (NFFP5), by the Swedish Governmental Agency for Innovation Systems. The initiative and project management for this project came from another (a third) division within SAAB, namely SAAB Aeronautics. Two subprojects were identified, one within Human System Interaction and one within Tactical Support with Situation Analysis. So far this project has resulted in two licentiate theses and about twenty other scientific publications (most in collaboration with researchers from SAAB). For a sample see below:

- Erlandsson, T., Helldin, T., Falkman, G. and Niklasson, L. (2010) Information Fusion Supporting Team Situation Awareness for Future Fighting Aircraft. In Proceedings of the 13th International Conference on Information Fusion (FUSION 2010), 26–29 July 2010, Edinburgh, UK.
- Erlandsson, T., Niklasson, L., Nordlund, P.J. and Warston, H. (2011) Modeling Fighter Aircraft Mission Survivability. In Proceedings of the 14th International Conference on Information Fusion (FUSION 2011), pp. 1038–1045, 5–8 July 2011, Chicago, IL, USA.
- Erlandsson, T. and Niklasson, L. (accepted for publication) An Air-to-Ground Combat Survivability Model. To appear in the Journal of Defense Modeling and Simulation: Applications, Methodology, Technology (JDMS). The Society for Modeling and Simulation International.
- Helldin, T., Falkman, G., Alfredson, J. and Holmberg, J. (2011) The Applicability of Human-Centred Automation Guidelines in the Fighter Aircraft Domain. In Proceedings of the 29th Annual European Conference on Cognitive Ergonomics (ECCE 2011): Designing Collaborative Activities, 24–26 August, 2011, Rostock, Germany, pp. 67–74. ACM.
- Helldin, T. and Erlandsson, T. (2012) Automation Guidelines for Introducing Survivability Analysis in Future Fighter Aircraft. In Proceedings of the 28th Congress of the International Council of the Aeronautical Sciences (ICAS) 2012, 23–28 September, 2012, Brisbane, Australia.
- Helldin, T., Falkman, G., Riveiro, M., Dahlbom, A. and Lebram, M. (2013) Transparency of military threat evaluation through visualizing uncertainty and system rationale.

available at <http://sourceforge.net/projects/desirer> and SWARD (System for Weapon Allocation Research and Development) a test bed for benchmarking weapon allocation algorithms against each other, available at <http://sourceforge.net/projects/sward/>

³ Information Fusion for Decision Support and Human System Interaction in Future Platforms (2010 – 2014) <http://www.his.se/nffp5>

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To appear in Proceedings of the 15th International Conference on Human-Computer Interaction (HCII 2013), 21–26 July 2013, Las Vegas, NV, USA. Springer-Verlag.

When the Information fusion project ended in 2011 a continuation project was established (funded by the Knowledge Foundation). This project was termed Uncertainty Management in Information Fusion (UMIF) and it had a budget of about 15 MSEK for the period 2011-2014. Two of the PhD-students who received their PhD-diploma during the Information Fusion project were hired by the university and one of the industrial PhDs who also got his diploma was working on the projects as a SAAB representative. The project had one work package specifically targeting Information fusion for detection of Airborne Threats. This work package has published about 5 scientific publications. For a sample see below:

Brax, C., Dahlbom, A. (2012) A Study of Anomaly Detection in Data From Urban Sensor Networks, in V. Torra, Y. Narukawa, B. Lopez, and M. Villaret (Eds.), Modeling Decisions for Artificial Intelligence, Lecture Notes in Computer Science, pages 185–196. Springer Berlin Heidelberg, 2012. ISBN (Print): 978-3-642-34619-4.

Dahlbom, A., Helldin, T. (2013) Supporting Threat Evaluation through Visual Analytics, in Proceedings of the 2013 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support, February 26-28, San Diego, CA.

In 2013 SAAB Aeronautics and the research group at the university applied for a new project within the Swedish National Avionics Research Program (NFFP6), by the Swedish Governmental Agency for Innovation Systems. This project, with the title Human-Machine Interaction for Distributed Decision-Making, was approved for funding 2013-2017.

The collaboration between SAAB and the University of Skövde has continued for almost twenty years. The quality of the collaborative research can be verified by the large number of joint publications and the fact that the consortium has the ability to compete successfully for external research funding. The collaboration has had a large positive impact on both parties. For SAAB the collaboration has resulted in a large number of joint publications, two adjunct professors, that two of their staff has received a PhD diploma and that two has received licentiate diploma (and expect to receive PhD diploma within one year), two new products, new networks of contacts and new knowledge. For the University the collaboration has resulted in that three new researchers have been hired, a large number of publications, that the research group has become nationally acknowledged in the area of information fusion, specifically anomaly detection, and that two simulation environments have been publically available. In addition to this the collaboration within education has meant that SAAB has hired several of former Skövde students to their Skövde office.

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Table C1.1.2 Template for impact cases**A long-term strategic effort for innovative collaborative research related to Open Source in the software systems domain.**

We want to make the case that the research conducted within the research centre in the area of open system draws from a long-term effort that aims to establish internationally recognised research related to openness in computing (i.e. open source, open standards, and related openness phenomena) which we, for a number of years, have perceived as an aspect of increasing importance⁴ in modern software systems. Further, open source is seen as an early exemplar of open innovation, which goes beyond sharing ideas as it involves open collaboration of production and more broadly open innovation⁵ that needs to be thoroughly understood.

Besides publication of research results in peer-reviewed scientific journals and conferences of high international standing there has also been a strategic effort to improve practice on a more short-term basis by means of conduction of innovative socio-technical research and related awareness and dissemination activities which is relevant to practice in the specific field (software systems). Conduction of collaborative research projects, which encompass direct involvement by practitioners representing specific organisations, have a **direct impact** on individuals and their organisations, and also a more **indirect impact** on those affiliated to other stakeholders indirectly involved. Those indirectly involved include individuals engaging and interacting with the project during different awareness activities, such as open workshops and other events during which project participants expose results and promote awareness of the project and its activities in a broader context.

The importance of establishing knowledge by means of undertaking **different types** of research projects, such as: fundamental research projects (e.g. as done in the FAS-project), applied collaborative research projects involving Swedish companies (e.g. as done in the ORIOS-project), and projects involving large international companies (e.g. as done in the OPEES-project) should not be underestimated. In most projects, the research design inherently implies that during conduction of the research project, researchers have direct interaction and collaboration with policy makers and practitioners. This has also contributed to making it easier to organise and undertake

⁴ In fact, it has been argued that “many of today’s most innovative products and solutions are developed on the basis of free and open source software (FOSS)”: Ebert, C. (2008) Open Source Software in Industry. IEEE Software 25(3): 52-53.

⁵ See, for example: Lundell, B. and van der Linden, F. (2013) Open Source Software as Open Innovation: Experiences from the Medical Domain, In Eriksson Lundström et al. (Eds.) (2013) Managing Open Innovation Technologies, Springer, pp. 3-16. & also: Eriksson Lundström, J.S.Z.; Wiberg, M.; Hrastinski, S.; Edenius, M.; Ågerfalk, P.J. (Eds.) (2013) Managing Open Innovation Technologies, Springer, ISBN 978-3-642-31649-4, 290p.

various activities (such as interactive workshops and open seminars) for a broader dialogue and communication of research results to the field of practice. Further, the iterative ongoing strategic effort also involves networking and establishment of close contacts with scientific journalists in order to strengthen an effective communication of research results to practitioners. For example, several news items and reports from dissemination activities have been an outcome of expressed interest from international and national journalists (both scientific and general journalists).

Research results have been discussed and scrutinized at a number of policy and practitioner events organised by the EU (e.g. the First International Digital Agenda Assembly) and by specific European governments (e.g. policy briefings organised in Brussels, by the UK Government and the Swedish e-Government initiative “E-delegationen”). Research results have had an impact on as results have reached **international and national policy makers**. Consequently, research findings have contributed to shape national policy on Open Standards (e.g. the UK Government national policy on Open Standards) and thereby influenced public and private sector organisations and more broadly the field of practice. Our **contributions** are **acknowledged** in a number of strategy and policy documents produced by various Swedish governmental agencies (e.g. The Swedish Competition authorities, “Konkurrensverket”) and the Swedish procurement office, see below). It should also be mentioned that researchers have contributed to policy discussions and panels with policy makers, including the responsible minister for the Swedish e-Government initiative. Further, research results and contributions are cited at EU (e.g. panel contributions at the First Digital Agenda Assembly, see below) and national contexts (e.g. a review of the evidence for Open Standards⁶ that contributed to the formation of the UK Government national policy on Open Standards⁷). In fact, research results from the centre have been cited (several times) in the report published by the UK Government which constitutes the scientific foundation and review of the supporting evidence behind the UK Government national policy on Open Standards.

In addition, the research results have had significant impact on the conditions for making business in the international and Swedish Open Source industry, partly due to investigation and public scrutiny of a number of misconceptions concerning procurement and adoption practices in Swedish public sector organisations. Specifically, research results have identified a number of misconceptions that have impacted on the conditions for a neutral and competitive marketplace (see, for example, Lundell, 2011).

⁶ “Open Standards in Government IT: A Review of the Evidence”:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/78891/Review-of-the-Evidence_CIPPM.pdf.

⁷ See, for example: “Open Standard principles”:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183962/Open-Standards-Principles-FINAL.pdf

The underlying research efforts contributing to the case were initiated several decades ago, and early research focus on evaluation, standardisation, interoperability and different types of lock-in effects in the area of software systems evolved into an interest in Open Source and Open Standards.

During the last decade, researchers within the centre have gained significant experience from involvement as partner in high profile research projects, and from different leading roles and collaboration in several international and national research projects. Experiences include project collaboration with academia, large international fortune 500-companies, as well as small companies and various other types of organisations (such as international and national Open Source associations). As partners and co-lead of a workpackage in the EU FP6 Calibre project (2004-2006), we were part of an internationally recognised research team that represented “the leading authorities on open source in Europe, or indeed worldwide” (LinuxWorld Australia, 2004-09-08). The CALIBRE project was led by the University of Limerick, Ireland, with the University of Skövde as one of 11 partners across Europe joined by an industry partner in China. In this project, which received an evaluation score of 29 out of 30 (including 5 perfect scores) for its proposal, we contributed to establishment of fundamental knowledge concerning the Open Source phenomenon. During this project, we established key contacts with leading researchers and practitioners in the area which have resulted in several successful collaborations and participation in a number of research projects. One key outcome was the instrumental role taken by a researcher in the group which contributed to the establishment of Open Source Sweden, an industrial association for Swedish Open Source companies⁸. Over the years, a symbiotic relationship has emerged between researchers within the centre and companies in the association with mutual benefits.

During and after our activities in the EU FP6 Calibre project, researcher within the centre have continued to develop and strengthen an extensive network of internationally recognised stakeholders and established strong informal links with key researchers and practitioners representing a variety of different organisations and companies in the area. For example, as technical manager and partner in the ITEA-project COSI (2006-2009) – Co-development using inner & Open source in Software Intensive products – a researcher representing the centre investigated the Open Source development model, with a specific emphasis on its potential for adoption in the embedded systems industry. Further, researchers within the centre have also been project leader and collaborated with Swedish companies in two collaborative research projects focused on Open Systems that have been funded by the Knowledge Foundation (“KK-stiftelsen”).

⁸ A researcher in the centre is a founding and acting chair of Open Source Sweden, which is now an internationally recognised industrial association in its field.

Efforts for fund-raising are dynamic and often opportunities evolve through the established networks. Researchers within the Software Systems Research Group are often invited to join and become partner in various research project initiatives, and it is also not uncommon that researchers initiate collaborative research and approach potential partners through the already existing (and evolving) network. Snowballing efforts are also used, and establishment of projects significantly draws from a systematic effort that the group has used for decades, namely to leverage from a very conscious long-term effort to establish close ties with relevant key stakeholders, utilising long-term relationships with key people representing internationally recognised organisations (e.g. Open Forum Academy, Open Source Sweden, Open Source Initiative, Free Software Foundation, Free Software Foundation Europe) and also key roles in the Swedish context (e.g. IT-standardiseringsrådet).

An underlying principle for conduction and maintenance of a long-term sustainable relationship with industrial organisation necessitates an in-depth understanding of different conditions for motives, goals, and conduction of development and research activities in collaborative projects. This requires mutual trust and respect, which in turn requires a very conscious effort to establish and maintain such long-term relationships.

Specific strategies used for establishing and maintaining a long-term successful relationship includes development and communication of scientific knowledge in an iterative process during which the way-of-working need to account for possible tensions between different goals (see “Figure 6.2”, section 6.3 in Lundell et al., 2005) which elaborate on the importance for balancing different goals. Further, ambitions have been to have impact both at international and national levels and the means for achieving such includes establishment of strategically important relationships with key actors. Such relationships are critical for maintaining a channel for communication and dialogue with the surrounding society concerning research results. Strategically important partners in the area of the case include key roles in the following:

- Open Source Sweden (an industrial association for Swedish Open Source companies),
- Open Forum Academy (an international network of researchers and academics in the area of openness),
- Open Source Initiative (the organisation that controls and maintains the Open Source definition and all its licenses),
- IT-standardiseringsrådet (a national advisory board for the Swedish e-Government initiative established by the Swedish government),
- PolarSys Industrial Working group (research partner in the Eclipse Industrial Working Group on long-term sustainable software systems),
- Eclipse Foundation (an internationally recognised Open Source foundation),
- a number of key individuals in several international and national organisations (established over the years in various collaboration projects and networks).

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(Selected) publications and presentations by researchers in the centre:**Recent publications relevant to the case include:**

- Lundell, B. (2012) Why do we need Open Standards?, In Orviska, M. and Jakobs, K. (Eds.) *Proceedings 17th EURAS Annual Standardisation Conference 'Standards and Innovation'*, The EURAS Board Series, Aachen, ISBN: 978-3-86130-337-4, pp. 227-240. [This paper has been invited for extension and publication in a journal]
- Lundell, B. (2011) e-Governance in public sector ICT procurement: what is shaping practice in Sweden?, *European Journal of ePractice*, 12(6), <<http://www.epractice.eu/en/document/5290101>>
- Lundell, B., Urquhart, C. and Pries-Heje, J. (2005) Serving Two Masters, In Avison, D. and Pries-Heje, J. (Eds.) *Research in information systems*, Elsevier Butterworth-Heinemann, Oxford, pp. 109-129.

Recent presentations relevant to the case include:

- “Observations on Innovation and Educational Lock-In in Swedish schools”, Contributions to a roundtable Discussion (host: OpenForum Europe), The First OpenForum Academy Conference, Brussels, 24 September 2012.
- “En skola för enfald eller innovation? En resultatredovisning från en aktuell forskningsstudie om IT-användning i svenska grund- och gymnasieskolor” (host: Hillar Loo, Open Source Sweden), A seminar about openness and transparency as a concept - enablers and inhibitors in IT for the public sector, Almedalen, Visby, 5 July 2012. (in Swedish)
- “Sustainable Open Source software communities: Experiences from business and software development ecosystems” (host: Gert Johansson, Combitech), OPEES Workshop, Jönköping, 14 June 2012.
- “Development with Open Source: A perspective on Challenges and Opportunities” (hosts: Erik Lönroth & Magnus Eriksson, Scania), Scania InfoMate, Södertälje, 4 June 2012.
- “Open formats in Swedish schools: Can you read and write ODF?” (host: OpenDoc Society), In The 8th ODF Plugfest, Brussels, 19-20 April 2012. [Presentation summarised @ European Commission Joinup: <https://joinup.ec.europa.eu/news/swedish-schools-confused-about-document-file-formats-and-applications>].
- “Öppen källkod & öppna standarder: Varför arkiven behöver denna öppenhet” (host: Håkan Löfblad, Riksarkivet), Riksarkivet, Stockholm, 10 April 2012 (in Swedish).
- “Public sector ICT procurement: Policy & Practice, Presentation & Workshop participation” (host: Anne-Marie Sassen): EU, The Importance of procuring open ICT systems, Digital Agenda Assembly workshop on Interoperability and Standards, The First Digital Agenda Assembly, Brussels, 16-17 June 2011.

- “Lock-in effects in the public sector: Why OSS & Open Standards are important”, Invited Presentation (host: Mathias Klang, IT-University): EU FP7 Counter Conference, Manchester, 23-24 March 2010.
- “Om betydelsen av öppna standarder och öppen programvara för en långsiktigt framgångsrik e-förvaltning”, Invited presentation (hosts: Eliza Roszkowska Öberg & Karl Sigfrid, Riksdagsledamöter): Framtidens e-förvaltning: Seminarium i riksdagen med Mats Odell, Sveriges Riksdag, Stockholm, 14 May 2009.
- “On the Importance of OSS for Europe”, hosts: Rodenbach, E. and Letellier, P., Presentation @ Open Source Software Workshop, ITEA 2 Symposium 2008, Rotterdam, 21 October 2008.

There is also documented evidence (in terms of contributions and explicit acknowledgements in a number of reports and documents) for the contributions provided by researchers from the centre, including:

- “Open Standards in Government IT: A Review of the Evidence: An independent report for the Cabinet Office by the Centre for Intellectual Property & Policy Management at Bournemouth University”: Expert contributions and research results from research conducted by researchers in the centre is cited in the report. This report constitutes the theoretical foundation for the UK Government national policy on Open Standards.
- “Upphandling av IT - inlåsnings effekter och möjligheter” : Contributions in the role of appointed expert (2012) as reviewer of a study on IT procurement and lock-in effects undertaken by Richard Wessman (von Lode Advokat AB) as commissioned from the Swedish Competition Authority (“Konkurrensverket”).
- Contributions to Action 23 on standards and public sector procurement in the Digital Agenda, via contributions to and feedback on (draft) procurement guidelines, and through participation as invited speaker (with presentation “Public sector ICT procurement: Policy & Practice”) and workshop participant in the First Digital Assembly (June 2011, Brussels).
- “Förstudie: Programvaror 2010”: Contributions as advisor to a pre-study on IT procurement of software applications (FS: 2010:01, Ärendenr 93-10-14) conducted by the Swedish National Procurement Services, Kammarkollegiet.
- Expert contributions to several Governmental remits, including: SOU 2007:47 (on IT-standardisation) and SOU 2009:86 (on e-Government strategies) specifically with expertise on Open Standards and Open Source.

In addition, researchers active in this case have also hosted and organised a number of open events related to Open Source in Skövde, including the IFIP WG 2.13 International Conference on Open Source Systems in 2009 and its associated doctoral consortium which received financial support from the Swedish Research Council “Vetenskapsrådet” and from the US National Science Foundation (to support travel and

PART C: 12

attendance for a diverse group of US Ph.D. students). The event was covered by the Swedish national radio (P1) in a science program⁹ ("Vetenskapsradion: Vetandets värld") and the event facilitated rich interactions between different stakeholder groups, partly promoted by a co-located event organised for Swedish Open Source industry.

Further, as an indication of practical relevance for the research conducted in the centre, researchers active in this case have co-authored publications together with representatives from more than 25 international companies and industrial Open Source foundations, including: Adacore, Airbus, Astrium, Atos Origin, Combitech, CNES, EADS Space Transportation, Eclipse Foundation, Nokia, Philips, SSAB Oxelösund, Telvent, TeliaSonera, Thales, Volvo IT, and Xipp.

To conclude, it is evident that a very conscious and pro-active effort for interacting with the surrounding society has been of mutual benefit for research activities within the centre, and for a number of stakeholders in private and public sector organisations. In particular, it is clear that our involvement as partner in the high-profile EU-project (EU FP6 Calibre) was an important foundation, which lead to significant networking with Swedish Open Source companies. This, in turn, lead to establishment (2007) of the Swedish industrial Open Source association (Open Source Sweden). We note that a founder (at the time representing RedPill, now RedPill Linpro) of one of the three founding companies (RedPill, Curalia, imCode Partner) behind the establishment of Open Source Sweden invited a researcher in the centre to take an active role in an initiative to raise awareness in society on these issues. This invitation was accepted, and lead to establishment (2007) of the Swedish industrial Open Source association (Open Source Sweden). As a researcher in the centre is a founding and acting chair in the association (since 2007), this has evolved into extensive interactions and collaboration with other researchers within the centre since then. Hence, as researchers and practitioners have developed a mutual thorough respect for the conditions on each 'side', there is now a sound basis for securing substantial partnerships and built on mutual trust when proposing, initiating and conducting collaborative research activities. It should be noted that companies also appreciate deep theoretical studies (e.g. as conducted in the FAS-project) on the open systems phenomena with a balance of deep theoretical understanding and practical experience, which perhaps is not surprising given that many of the companies are knowledge intensive, highly specialised and international market leaders in their specific niche.

⁹ <http://sverigesradio.se/sida/avsnitt/81454?programid=412>



UNIVERSITY
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Self-assessment

The Systems Biology Research Centre

ARC13 – SYSTEMS BIOLOGY

The following document describes the research and collaboration of the Systems Biology research centre at University of Skövde. The document includes indicators on research activities, research initiatives and collaboration in research in relation to academic, business, and public partners. The document also includes a qualitative self-assessment of the strengths, weaknesses, opportunities and threats (SWOT) of the centre. The indicators aim to describe research activities in specific areas as well as in multi-disciplinary fields. Apart from direct research quality assessments, a number of different aspects are elucidated; description of the research field, research environment and infrastructure, research output, impact, engagement and co-operation with society (which in this document denotes organisations within business and public sector, non-governmental organisations, the public, but not including other academic institutions) and opportunities for renewal and actions for successful development. The document also includes two case descriptions identified by the centre as particularly important or significant (see C). The document is structured in three parts:

Part A – Strategic information about the centre (general description and SWOT-analysis)

Part B – Quantitative data describing the centre (general information, research output and co-operation with society)

Part C – Case descriptions (two impact cases)

The parts are complementary. Information provided in each part is to be used to support and deepen the information presented in the other.

ARC13 generally assesses the period from January 2007 to the end of December 2012, although some of the indicators cover a shorter period of time. The expert panels are asked to assess the quality of research (and collaboration) at the centre in an international perspective based on the instructions given in the *Terms of reference* (Appendix 1). In particular, the panels are asked to identify **strong research activities, strong collaboration with society and potentially interesting opportunities for development.**

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Part A: Strategic information

Table 0 – Name of the UoA	
Name of Unit of assessment	SYSTEMS BIOLOGY
Coordinator of Unit of assessment	Björn Olsson

A1. Description of the research

This self-evaluation concerns the Systems Biology Research Centre, which consists of six research groups with a common interest in studying complex biological systems. The centre was originally formed by four groups with specializations in different biological systems. The aim was to explore and strengthen collaborations between the groups, rather than trying to convert all researchers into systems biologists. In 2012, the centre consisted of five groups: i) *Infection Biology*, ii) *Bioinformatics*, iii) *Tumor Biology*, iv) *Physiology, Pharmacology and Toxicology*; and v) *Ecological Modeling*. By January 2013 the centre expanded with a sixth group: *Consciousness and cognitive neuroscience*. This evaluation includes all six groups that currently belong to the centre.

The centre uses a broad definition of systems biology, viewing it as the study of complex biological systems at various levels of detail, using a combination of experimental, mathematical, statistical and computational methods. The aim of this broad definition is to be inclusive and at the same time highlight the systems biology aspects of the research. It includes the study of complex biological systems, as well as development of computer-based tools applied in biological research.

The following sub-sections will summarize the primary missions and goals of the six research groups. Collaborations between groups will be pointed out, since the primary mission of the centre as a whole is to encourage and strengthen multidisciplinary collaborations with a systems biology approach.

The **Infection Biology** research group focuses on the development and use of mathematical/computational models and bioinformatic tools to understand dynamical processes in immunology and microbiology. The experimental work in the group is aimed at generating high quality quantitative data that can be used for parameter estimation and to verify results generated by the mathematical models. The group is also involved in traditional experimental

projects that focus on e.g. analysing bacterial strains in order to determine bacterial markers for identifying patients suffering from septicaemia. In addition, the group has recently developed a special focus on gene expression analysis in stem cell development. In particular the stem cell research uses a lot of bioinformatic competence and involves researchers with biological and computational training. The group currently collaborates with the research groups in Bioinformatics and Tumor Biology on common approaches to study gene regulatory systems.

The primary missions and goals for the Infection Biology group are to:

- understand how immune cells are activated and how they discriminate between self and non-self molecules
- understand complex gene regulatory mechanisms involved in the cell-fate decision in stem cells by analysing mRNA, microRNA and DNA methylation data, and to improve the functionality of stem cell derivatives
- develop and evaluate molecular methods and computational approaches supporting earlier diagnostics of sepsis patients
- understand how virulence genes are regulated in the human pathogenic bacteria and to identify new genes that are important for pathogenicity

The **Bioinformatics** research group was formed by computer science researchers and focuses on developing and applying algorithms for analysis of biological data sets. The group's research includes development of algorithms, databases and software, as well as solving biological research problems with such tools. An important strategy for the group is to work in close collaboration with researchers from other groups, since this gives access to experimental data and ensures that the research is of high relevance in terms of biological applications. In the early years of the evaluation period the main collaboration was with molecular biologists and focused on the use of bioinformatics in studies of stem cell differentiation (a research direction that is nowadays managed by the Infection Biology group). In recent years, the focus has shifted more towards discovery and evaluation of biomarkers for cancer, in collaboration with the Tumor Biology group. A third research orientation is to apply bioinformatics in studies of cold adaptation in plants, which is done in collaboration with plant scientists from Göteborg University and Lund University.

The primary missions and goals for the Bioinformatics group are to:

- develop new algorithms for analysis of biological data which will facilitate the analysis of large-scale transcriptomic, genomic, pathway and network data sets

- apply machine learning and other advanced computational techniques to analyse large-scale biological data sets
- discover and statistically evaluate molecular biomarkers for diagnosis, prognosis and classification in various diseases, with a special emphasis on cancer
- apply bioinformatic methods to discover and evaluate biomarkers for other applications, such as cold-hardiness in plants, stem-cell differentiation, and fertility in germ cells

The **Tumor Biology** research group uses both human clinical material and different model systems along with advanced molecular techniques to search for gene variants underlying several human cancer types, including endometrial cancer, mammary cancer, neuroblastoma, and colorectal cancer. Except for the human clinical material, model systems used by the group include human and rat tumor cell lines, a rat model of endometrial adenocarcinoma, and fruit fly. The overall objective of the research is to identify novel biomarkers, as well as to gain a better understanding of cancer pathways, and thereby providing new insights into diagnosis, prognosis and treatment for different cancer forms. Since the analysis and interpretation of the experimental data is largely dependent on bioinformatic methods, the research is carried out in close collaboration with the Bioinformatics group (including shared PhD students with affiliation to both groups).

The primary missions and goals for the Tumor Biology group are to:

- determine and analyze chromosomal aberrations in a rat model of endometrial adenocarcinoma
- examine the impact of miRNA expression on the development of prostate cancer and endometrial cancer
- investigate whether aberrant genes and proteins in cancer can be used as biomarkers for cancer and be potential targets for future cancer treatment

The research group **Physiology, Pharmacology and Toxicology**, also known as **P2T**, was established in 2008 and has grown very rapidly to more than 10 members in 2012. The academic background of the members of P2T is diverse, among others bioinformatics, biomedicine, microbiology and molecular biology. Therefore, the research projects in this group are multidisciplinary. The group takes advantage of various model systems, combining genomics, transcriptomics, proteomics and other modern molecular biology tools to study human cells, as well as plant, bacterium and fungal materials at different levels. The bioinformatics research of this group focuses on developing new algorithms for data analysis and mathematical models for understanding the biological functions of the genes, proteins or other materials. A significant part

of this group is focused on research relevant to developing countries. This is done with the aid of the Swedish International Development Cooperation Agency (SIDA) under the framework of the Partner Driven Cooperation (PDC).

The primary missions and goals of the P2T research group are to:

- study immune system components and environmental factors in patients with chronic non-bacterial prostatitis and long term pain by using proteomics and clinical data
- examine the basic mechanisms underlying the role of 1,25-dihydroxyvitamin D3 in regulating CaP cell biology using well-characterized CaP (prostate cancer) cell models; LNCaP cells (human prostate adenocarcinoma), PC3 cells (human prostate adenocarcinoma), PNT1A (human prostate epithelial), and PNT2 (human prostate epithelial)
- characterize the function of two *Arabidopsis thaliana* genes, *ACR2* and *PCS1*, that can be utilized for generating new varieties of cultivated crops for avoiding arsenic contamination of human foods
- investigate novel bacterial strains that can be used for reducing or eliminating arsenic concentrations in contaminated water or industry effluents

The research group in **Ecological Modeling** has an emphasis on modeling ecological systems including the human impact and utilization of ecosystem services. The research involves the sensitivity of food webs to loss of species, processes of speciation, bio-indicators of healthy eco-systems, life-history-analysis of commercial fish, sustainable management of fisheries (applied to the Baltic Sea), optimization of transports in regional farming systems, minimizing risks of disease outbreaks in livestock, and optimized fertilization within precision farming.

The primary missions and goals of the Ecological modeling group are:

- to provide new knowledge and decision aid for sustainable use of biological resources
- to protect ecosystems, their organisms and their services
- to increase the knowledge of system properties of eco-systems

The research group **Consciousness and Cognitive Neuroscience** studies different states of the conscious human mind: Sleep, dreaming, anesthesia, hypnosis and meditation. Important areas of research include also empathy, emotions and pain. The philosophical parts focus on whether the biological and physical sciences can describe and explain consciousness. Furthermore, the group also explores the ontological implications of key theories of modern physics (quantum theory and relativity).

The primary missions and goals for the group Consciousness and cognitive neuroscience and are to research questions such as:

- What are the neural correlates of visual consciousness?
- How to define and measure consciousness during anesthesia; how does the state of being conscious emerge following the unconscious state?
- Do subjective contents of dreams support the evolutionary hypothesis that dreaming functions as a preparatory simulation of waking life; for example as a simulation of evolutionary important social interactions?
- Do some highly hypnotizable individuals enter a qualitatively different state of consciousness? What are the neural mechanisms of suggested automatic changes in the content of consciousness such as experienced vivid hallucinations?
- Is it possible to enhance the empathic capacities of people (specifically the emotional aspects of empathy) using information technologies such as computer games? Can these changes be measured using physiological measurements (Oxytocin levels, EEG, etc.)?

A2. Summary of the scientific results

All research groups in the systems biology centre strive to publish their results in peer-reviewed journals of high impact. During the evaluation period we published a total of 220 journal articles (Table B2.2.1), which was 37% of the total (593) for the whole university. The number of journal articles per year is increasing (Figure 1). The average Impact Factor (IF) of the journals was 3.21 and the field normalized IF was 1.11 (Table B2.2.2). In other words, the journals where we published our results had an impact 11% above the average for our fields. According to the Norwegian score, 21% of our articles were published in journals that are among the top 20% ranked.

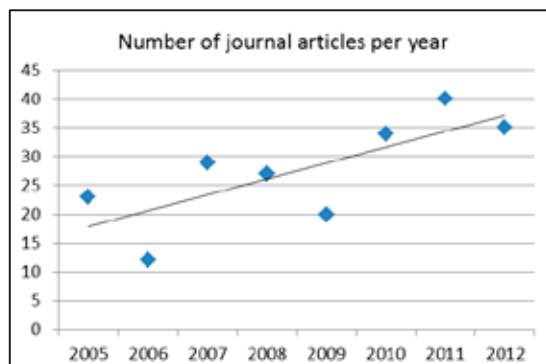


Figure 1. Number of articles published per year in peer-reviewed scientific journals by members of the Systems Biology centre.

Considering all types of publications, we produced 319 publications in total (Figure 2), corresponding to 40 publications per year (Table B2.2.2). During the evaluation period our work was cited 1409 times, which were 53% of all citations (2658) made to publications from the University of Skövde. Both the average field normalized IF and the Norwegian score was higher for Systems Biology than for any other centre in the university.

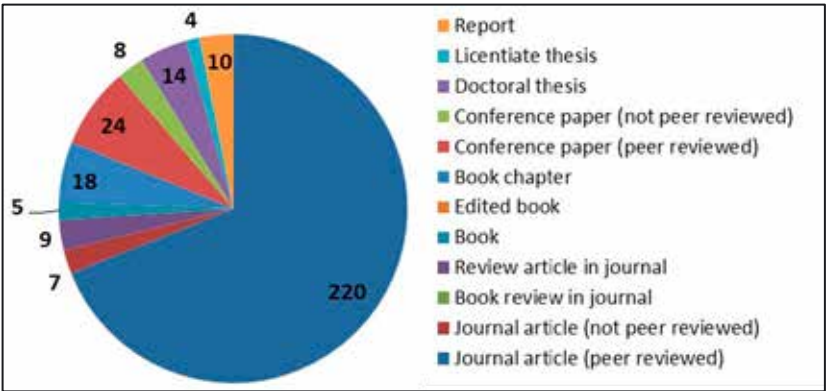


Figure 2. Publication profile. The majority of publications (220 of 319, i.e. 69%) were articles in peer-reviewed scientific journals, with an average Impact Factor of 3.21 (or 1.11 if normalized to the average of the fields). Our publications were cited 1409 times, which was 53% of all citations made to publications from the University of Skövde.

The following text gives examples of results and contains references to a small selection of our publications (30 of the total 319). Some of the results are described in greater detail in part C of this report (Case studies) and in chapter A4.1 (Collaboration with society).

The **Infection Biology** group published 46 peer-reviewed articles in the period 2005-2012, in journals with an average IF of 3.36. The results include the following examples.

Mathematical/computational modelling of pathogenic bacteria and the immune system. In the field of microbiology, we have been analysing the pathogenicity of several important bacteria. In *Staphylococcus aureus*, *Streptococcus pneumoniae* and *Pseudomonas aeruginosa* for example, we have shown that most virulence factors are expressed in a growth-phase dependent manner governed by the auto-inducible quorum sensing (QS) systems and how different regulators work together to control transcription of virulence genes (Gustafsson et al. 2009). We have also recently performed spatial modelling of how bacteria form biofilms (Fagerlind et al. 2012). The simulations revealed the bacterial death mechanisms during the developmental phases of the biofilm. In addition, we studied different strategies aiming at a decreased pneumococcal

burden in the community (Karlsson et al. 2008). In the field of immunology, we have developed a range of different types of mathematical models to quantify and simulate T cell activation. For example, in collaboration with the University of Oxford, we developed a mathematical model describing the kinetics controlling the co-stimulation of T cells. The simulations revealed how binding affinity, stoichiometric properties, expression levels, and, in particular, competition effects all profoundly influenced molecular complex formation at the immunological synapse. Using this model, we have recently predicted the therapeutic efficiency of the different forms of CTLA4Ig fusion protein (Jansson and Davis, 2011).

Differentiation of human pluripotent stem cells. During the evaluation period we have developed a special focus on gene expression during stem cell differentiation towards hepatocytes and cardiomyocytes, which will be thoroughly described in case study 1 (see part C of this report). We recently performed detailed transcriptional studies of cardiomyocytes derived from human embryonic stem cells (hESCs) and analysed the expression of miRNAs and mRNAs in these cells and compared them to heart tissue samples (Synnergren et al. 2012). We also performed global gene expression studies on tissue samples from different locations in the heart by comparing biopsies from the right atrium and the left ventricle collected *in vivo*. In a recent study we also demonstrated how the differentiation of hepatocytes from hESC was improved by the use of a 3D bioreactor system. Apart from a large number of publications, the work has also resulted in two patents relating to differentiation of stem cells into cardiomyocytes (see Table A2.2).

The **Bioinformatics** group published 34 peer-reviewed articles in 2005-2012, in journals with an average IF of 3.30. The research results include the following examples.

Machine learning algorithms for tumor classification. We recently developed a new machine learning algorithm, called decision trunks, for classification of tumor samples using expression data (Ulfenborg et al. 2013). The algorithm is based on decision trees, but includes a number of modifications designed to produce smaller and more interpretable classifiers, while also increasing the robustness to noisy data and improving the classification accuracy. The algorithm was thoroughly evaluated on datasets from a wide range of cancer types and classification tasks and was found to as well, if not even better, than other state-of-the art classification methods. When applying other machine learning algorithms to cancer data sets (in collaborations with the Tumor Biology group) we have identified expression signatures for various classification tasks, such as separating between normal and malignant tissue in prostate (Carlsson et al. 2011) and endometrial cancer (Karlsson et al., 2009),

as well as for survival prediction and for classification of tumors into treatment groups.

Bioinformatics in the study of cold-adaption of plants. In collaboration with the partner company CropTailor and researchers at Göteborg University, we studied the expression of genes involved in cold stress responses in the crops oat and rice, as well as in the model plant *Arabidopsis*. Most stress responses in plants are multi-genetic traits, involving many genes that interact in an intricate regulatory network and which rely on the combinatorial control of several transcription factors. We have shown that this is also the case for cold stress responses in rice and *Arabidopsis* (Lindlöf et al., 2009), and we also developed different algorithms for identifying which regulating genes work together to accomplish the cold stress responses (Chawade et al., 2007).

The **Tumor Biology** group published 20 peer-reviewed articles in 2005-2012, in journals with an average IF of 2.68. It is important to note that one professor and one associate professor joined the group in 2009 and 2010 respectively, and thus nine of their publications since 2007 are not included in the statistics given above. Moreover, three associate professors and one junior lecturer joined the P2T research in 2009, and thus none of their publications are included here. The research results of the Tumor Biology group include the following examples.

Genetic changes during tumour development in a rat model of endometrial adenocarcinoma (EAC). Characteristic genomic and genetic changes are common features of cancer cells and we have characterized these changes in a rat model of EAC. We concluded that certain chromosome regions are recurrently engaged in chromosomal copy number changes, and it is obvious that the genetic background has a large impact on the path of tumourigenesis (Falck et al., 2012). We have also identified a commonly deleted region on RNO10 with potential tumour suppressor activity in the EAC susceptible strain, and we narrowed down the candidate region, and recognized *Inpp5k* and *Mmyo1c* as the best candidate target genes. The results in the rat model can be used in corresponding human clinical material as revealed by conclusive molecular evidence in support of the resemblance of the rat EACs to those of human (Nordlander et al. 2007; Samuelsson et al. 2009). Specific expression patterns involved in EAC tumourigenesis were studied by global gene expression profiling and hierarchical clustering in combination with statistical methods uncovered several genes to be differentially expressed between tumour samples and normal control samples. The gene *Gpx3* was selected for further studies and it was demonstrated that loss of expression of the gene is correlated with epigenetic mechanisms (Falck et al., 2010).

MicroRNA expression signatures in prostate cancer. MiRNA expression profiling

was performed to identify a marker set that could be used to distinguish between normal and malignant prostate tissues. In collaboration with the Bioinformatics group, we identified a signature based on nine differentially expressed miRNAs that with high accuracy (85%) could classify normal and malignant prostate tissues. Significant differences in miRNA expression between normal and malignant prostate tissues indicate that these small RNA molecules might be important in the biogenesis of prostate cancer and potentially useful for clinical diagnosis of the disease (Carlsson et al., 2011).

PI3K catalytic subunits as potential biomarkers and targets for future cancer treatment. We identified an alternatively spliced *PIK3CD* transcript encoding a previously unknown protein, p37 δ , and showed that this protein was up-regulated in human ovarian and colorectal tumors. The p37 δ protein had a strong interaction with the PI3K regulatory subunit p85, but lacked the catalytic kinase domain of p110 δ . The protein p37 δ also bound to the small GTPase RAS, and a strong correlation between the protein levels of p37 δ and RAS in colorectal tumors was revealed. Thus, p37 δ appeared to be a novel tumor-specific isoform of p110 δ with growth-promoting properties (Fransson et al. 2012).

The **P2T** group published 70 peer-reviewed articles during 2005-2012, in journals with an average IF of 2.44. The research results include the following examples.

Chronic non-bacterial prostatitis and long term pain. We have recently shown that proinflammatory cytokines, measured by venous puncture, contribute to chronic pelvic pain syndrome (CP/CPPS) and that the cytokines are also noticeable in several other diseases involving chronic pain. We have previously shown that there is a strong correlation to ambient temperature of CP/CPPS (Hedelin et al, 2012).

Vitamin D and prostate cancer: new targets for prostate cancer therapy. We have modelled the tertiary structure of a novel vitamin D3 receptor and predicted putative binding sites for 1,25-vitamin D3 (Karlsson et al, 2010).

Development of new varieties of cultivated crops for protection of arsenic poisoning in human foods. We have identified four key genes that might be involved in uptake, transport and sequestration of arsenics in plants by using data mining and other bioinformatics tools. We also developed a kinetic model of arsenic uptake and accumulation in the model plant *A. thaliana* to exploit strategies for reducing arsenic content in the edible parts of plants (Lundh et al, 2010). By including a T-DNA tagged mutant of *A. thaliana* in our investigations, we have validated this *in silico* model by *in vivo* experiments showing that one of the four key genes ACR2 (Arsenic reductase 2) is indeed

involved in arsenic accumulation in plants (Nahar et al. 2012).

Bioremediation of toxic metals and other pollutants for protection of human health and the ecosystem. By involving directed evolution we have discovered a novel soil borne bacterium, B1-CDA, that can effectively remove arsenics from the contaminated source. This bacterium can therefore contribute to protection of several hundred million people world-wide from suffering from lethal diseases caused by arsenic poisoning and other pollutants (Prakash et al. 2013).

The group **Ecological Modelling** published 33 peer-reviewed articles in 2005-2012, in journals with an average IF of 4.72. The research results include the following examples.

IBAM: Integrated Bayesian risk analysis of ecosystem management in the Gulf of Finland. The Baltic Sea ecosystem has undergone dramatic changes, so-called ecosystem regime shifts, during the past four decades. Baltic Sea herring (*Clupea harengus*) spawning-stock biomass has declined to a third, and weight-at-age has halved as a result of food shortages and competition with sprat (*Sprattus sprattus*). The management objective for the herring stock is currently in transition from precautionary to maximum sustainable yield (MSY). This warrants new biological analyses of drivers of productivity and compensatory dynamics. The project developed a model taking into account ecological drivers for stock production and how it affected MSY (Holmgren et al. 2012). Retrospective application of the functions is indicative of overfishing of herring in the 1990s and early 2000s, resulting in an estimated net loss in yield, with a landing value of some €440 million. Within IBAM we investigated the performance of a new quota system, Bayesian quota, and compared it with the TAC regulation of today. The Bayesian quota has many attractive advantages over TAC.

Specialization and sympatric speciation. We modeled the cue recognition trait of exploiter populations with artificial neural networks enabling to discriminate beneficial resources from detrimental based on their unique signals. When haploid exploiters and the resources coevolve, we find that coevolution can be cyclic with saltational changes between stages of specialization and generalization. In simulations when the signals of the resources cannot mutate but the exploiters have a diploid genome and reproduce sexually, disruptive selection stemming from exploiters specializing on different resources can overcome the homogenizing effect of sexual recombination when exploiters mate randomly and produce a functional genetic polymorphism with specialized exploiters. Selection against accumulating mutations in niche preference genes can in this case select for reproductive isolation and drive speciation (Norrström et al. 2011).

Disease spread in contact and animal movement networks: improving decisions and interventions. We have earlier developed methods and techniques to process data from databases to ensure accuracy, developed statistical methods to estimate probabilities of transports between holdings within the network and developed algorithm for generation of virtual networks (Lennartsson et al. 2012). We have described and analyzed transportations networks by network analysis and also evaluated the importance of difference transportation structures and production types for the risk of disease spread. To conclude our results it is important to have databases that are up to date due to the dynamical changing market. For the within country dynamics it is important to take into account the country specific transportation structure and different production types.

Freshwater mussels. In 2007 and 2008, we surveyed mussel localities in the region of Västra Götaland and found that only one third of the 67 populations showed a satisfactory recruitment status. To further explore the survey method we compared the spatial distribution of two unionid species, *Anodonta anatine* and *Unio tumidus* (Jonsson et al. 2013). Our results showed a preference of juveniles to be burrowed in the sediment but also a large difference in burrowing frequency between species. This result may be due to the timing of our field survey that coincided with the period of glochidia release for *U. tumidus*. We concluded that a monitoring program for freshwater mussel populations needs to be carefully planned in time.

Food webs. The structure and dynamics of food webs, and how this both affects and is being determined by characteristics of species, has been an important focus in the research group. In one doctoral project we used a modeling approach to study the relationship among food web structure, species interactions and the probability of extinction of species. Among other things, we were able to show that species can have different extinction risks in different food web positions or structures, with the position and type of strong interactions being important aspects of the structure of a food web that affect extinction risks of species. We furthermore suggested a new approach for identifying species vulnerable to environmental stochasticity in a food web setting that focuses on characteristics of the time series of species, with increased autocorrelation in population fluctuations being a potential indication of increased extinction risk. In another food web project we have performed a pioneering analysis of the scaling of body masses of predators and prey across trophic levels and ecosystems (Riede et al. 2011), showing systematic differences across habitats and consumer types, as well as a previously not documented tendency for a decrease in the predator-prey body mass ratio with the trophic position of the predator.

The group **Consciousness and Cognitive Neuroscience** published 47 peer-reviewed articles in 2005-2012, in journals with an average IF of 2.91. The research results include the following examples.

Subjective experiences during anesthesia. Our research (Långsjö et al., 2012, Noreika et al., 2011) has addressed the differences between the conscious and the unconscious state of the brain, when anesthetic agents are used to manipulate the state of consciousness. We have found in our PET studies that the re-emergence of consciousness after a period of loss of consciousness is correlated with increased activity mostly in subcortical mechanisms rather than the neocortex. We also found that the definition of consciousness is unclear in anesthesiology as compared with consciousness studies. “Unresponsiveness” should not be used as a definition of “unconsciousness”. Our study demonstrated that the majority of subjects who were anesthetized so that they became unresponsive (and would therefore fulfill the definition of “unconscious” in anesthesiology), nevertheless had had subjective experiences during the unresponsive period, which means that they still retained internal conscious experiences. In our future PET studies of anesthesia and consciousness, we will explore the emergence of consciousness after unconsciousness and the distinction between responsiveness and consciousness in more detail.

Neural mechanisms of hypnosis. In our research (Kallio et al., 2011) we showed, for the first time, a behavioral pattern that was associated with hypnosis but could not be imitated or simulated by non-hypnotized individuals. More specifically we showed that a Hypnotically Induced Stare (HIS) was accompanied by large, objective and inimitable changes in the patterns of eye movements in the case TS-H. During hypnosis the amplitude, velocity and frequency of reflexive saccades were radically suppressed, and the fixation time was increased.

Neural correlates of visual consciousness. Visual consciousness has been one of our major lines of research since the 1990's. First, we have studied the electrophysiological (EEG, ERP) correlates of visual consciousness, and a series of studies during the last 10 years has led to the discovery of a consistent pattern of event-related brain potential correlates of visual consciousness (reviewed in Koivisto and Revonsuo, 2011).

Subjective experiences during dreaming. Dream consciousness as a simulation of waking consciousness has been one of our major lines of research. This idea was first formulated as the Threat-Simulation Theory of dreaming (Valli and Revonsuo, 2009) and later we developed new methods to test the theory and tested it in a series of empirical studies, which for the most part supported the predictions of the theory. In brief, we have found threat simulations to be

more frequent and more dangerous in dreams than in the waking life of normal subjects, and exaggerated in children with traumatic experiences.

Table A2.1. Selected peer-reviewed publications. Underlined author names indicate members of the research centre.

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- tumidus*: implications for environmental monitoring. *Hydrobiologia* 711(1):61.
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- Karlsson D, Jansson A, Normark BH, Nilsson P (2008) An individual-based network model to evaluate interventions for controlling pneumococcal transmission. *BMC Infectious Diseases*. 8: 83.
- Karlsson S, Olsson B, Klinga-Levan K (2009) Gene expression profiling predicts a three-gene signature of endometrial adenocarcinoma in a rat model. *Cancer Cell International* 9:12.
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- Koivisto M & Revonsuo A (2010) Event-related brain potential correlates of visual awareness. *Neuroscience and Biobehavioral Reviews*, 34(6):922-34.
- Lennartsson J, Håkansson N, Wennergren U, Jonsson A (2012) SpecNet: A spatial network algorithm that generates a wide range of specific structures. *PLoS ONE* 7(8), e42679.
- Lindlöf A, Bräutigam B, Chawade A, Olsson O, Olsson B (2009) In silico analysis of promoter regions from cold-induced genes in rice (*Oryza sativa* L.) and *Arabidopsis thaliana* reveals the importance of combinatorial control. *Bioinformatics* 25(11):1345-1348.
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Table A2.2. Other major research outputs

Type of output	Main person responsible	Description	Date when became publicly available
Genetically modified plant	Abul Mandal	Genetically modified tobacco plants to reduce or eliminate arsenics from contaminated soil	2013
Novel bacterium	Abul Mandal	Bacteria for removal of arsenics or chromium from contaminated water or industry effluents	2013
Bioreactors for bioremediation	Abul Mandal	Bioreactors for bioremediation and recycling of heavy metals and other toxic substances	2013
Software	Andreas Jansson	Systems Biology Graphical Notation (SBGN) in the	2010-11-01

		software PathwayLab	
Experimental protocols	Jane Synnergren	Protocols for developing functional hepatocytes and cardiomyocytes derived from stem cells	2012
Patent	Jane Synnergren	Cardiomyocyte-like cell clusters derived from hBS cells (W02009036982)	2009-03-26
Patent	Jane Synnergren	Novel microRNAs for the detection and isolation of human embryonic stem cell-derived cardiac cell types (W02011EP59785)	2011-06-14
Reference points for fisheries	Noél Holmgren	A model for calculating maximum sustainable yields of fish stock in the Baltic Sea	2012
SpecNet	Annie Jonsson	Software for generating virtual networks	2012
miREC	Björn Olsson	Database of miRNAs associated with endometrial cancer	2011

A3. Research environment and infrastructure

A3.1 Organisation of the UoA

Organisation and management

The organisation of the Systems Biology Research Centre can be described bottom-up as consisting of research groups, heads of research, the management group, and the head of the management group. The centre was originally formed by four research groups, which later became five when one of the groups divided into two. Currently, there are six groups, since an additional group joined the centre in January 2013.

Each group has a Head of research who is a professor or associate professor (currently three of each category). The head has primary responsibility for coordinating the research in the group, developing the group, and taking the role as representative for the group. The head of research is usually (but not necessarily) the most senior researcher in the group.

The Systems Biology Research Centre has a management group, consisting of the six heads of the groups. The management group holds biweekly meetings

to discuss issues concerning the centre. Every second meeting (i.e. once per month) is of a more formal nature, and in these meetings also the head of department participates. This is the main forum for direct communication between the research centre and the department concerning important decisions influencing both parties. In the formal meetings also a representative of the PhD students is invited, so that the students' views on important decisions can be discussed. Every second meeting (i.e. also once per month) is a working meeting with attendance limited to the six group heads. In the working meetings the group heads work together on e.g. large funding applications, evaluation reports, or applications for examination rights.

The meetings of the management group are coordinated by the head of the management group. This position is rotated between the group heads on a yearly basis. The head of the management group also acts as representative of the research centre when we have guests, when presentations of the centre are given, in discussions with higher management, etc. Funding for this organisation has been provided by the university. We have received 500 thousand SEK annually, which currently covers 10% of full-time for the head of the management group, 5% for the heads of research groups, and the remaining sum to cover the costs of a yearly two-day workshop. Decisions by the management group are taken by all group heads on an equal basis, either by consensus or (more rarely) by voting.

The centre has a biweekly seminar series where all members (currently approximately 50 people) are invited to participate. The seminar schedule is organised by two PhD students, and this responsibility is rotated among the students on a half-yearly basis. A typical seminar consists of one or two research presentations and a discussion of some currently important topic. The presentations are made either by members of the centre or invited guests. It is also common practice for the PhD students to use these seminars for practice rounds of their presentations when preparing for their defence. In addition, the seminars are frequently used by the management group to communicate or discuss important decisions to everyone in the centre.

Quality-securing the research

The perhaps most important form of quality control is our publication record. Our research results are predominantly published in peer-reviewed journals. During the period 2005-2012 we published 220 articles in peer-reviewed journals, corresponding to 27.5 articles per year, or around one article every second week (Table B2.2.1). The average Impact Factor (IF) of the journals was 3.21 and the field normalized IF was above 1 (1.11, Table B2.2.2). This means that our research is constantly being quality assured in terms of scientific merits by peers in the field.

The University of Skövde distributes a large part of its research funding based on the scientific quality and quantity of the research carried out in each centre, as measured by publication success. This is done in a two-step process. First, a small sum of funding is awarded for a publication, where the highest sum, 10 000 SEK, is awarded for an article in a peer-reviewed journal, the second highest, 5 000 SEK, for a peer-reviewed paper in a conference proceeding, and so on. Thus, the 220 journal articles (corresponding to 69% of our publications) brought in around 2 million SEK in funding during the period 2005-2012. The second step in this quality-encouraging process is that a certain sum of funding is divided up between the centres based on their publication success, in comparison with each other. Since the calculation favors peer-reviewed journal articles, this system encourages external quality control of research results. Our centre has done well in this quality-encouraging competition for funding, since our 220 journal articles constituted 37% of the total number of journal articles (593) published by researchers from University of Skövde during the evaluation period.

Quality of the research is also secured when applying for external funding. Of the funding spent by the Systems Biology centre in 2011 approximately half (48%, Table B.1.2.2) came from external sources. Thus, a large proportion of the funds were awarded after peer-reviewing of the research plans and the merits of the involved researchers.

Although our university does not have PhD examination rights for systems biology, the quality of PhD projects is secured since all our students are registered in PhD programmes at other host institutions (e.g. Örebro University, Göteborg University, Lund University, Karolinska Institute). One could argue that this results in better quality control than usual, since the students have supervisors at both institutions. Defense of the PhD thesis usually takes place at the host university where the student was registered and of course with expert evaluators and opponents who are leading researchers in the field.

Structure of efforts at fund-raising

As illustrated in Figure 3 (based on Tables B.1.2.1 and B.1.2.2) around 40% of the centre's spending consists of faculty funding, which is awarded in competition with other research centres based on publication success, as discussed in the preceding section, and also based on the amount of external funding the centre has. An additional 12%, labelled "Competence", also comes from the university, and is funding for research time allocated to individual researchers based on the subjects they teach in.

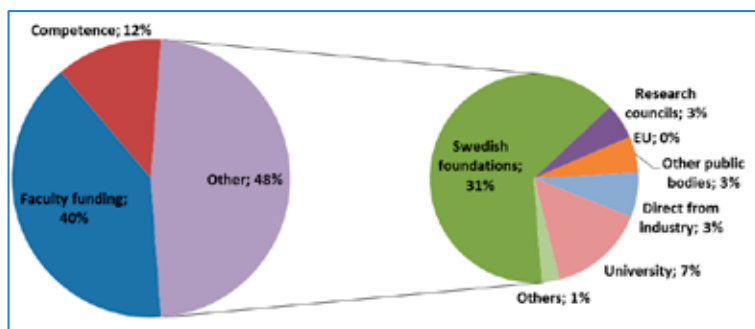


Figure 3. Sources of the research funds spent in 2011, based on tables B.1.2.1 and B.1.2.2. The pie on the right shows the sources of external funding. The label “University” refers to external funding coordinated by other universities.

The 48% of the funds which come from external sources is mostly (about two-thirds) from Swedish foundations, where the Knowledge Foundation (KF) is the main source. This funding is awarded to research projects carried out in collaboration with industry. The KF has several funding programmes, which all share the condition that the amount of in-kind funding from industry partners must match the amount of funding awarded by the foundation to the university. As can be seen in table 3.2.3 the number of industry partners more than doubled during the evaluation period, to reach 22 in 2012. This is largely due to successful participation in KF funding programmes. In 2011 the University of Skövde was selected by the foundation as a prioritized academic partner, a so called “KF environment”. This means that the university can work in closer collaboration with the KF to finance research of strategic importance for building up the university’s research environment. University of Skövde was the first university in Sweden to receive the KF environment status, and currently two more universities (University of Mid-Sweden and Halmstad University) are in a qualification process. An example of the closer collaboration with the KF is that funding in key KF funding programmes is now (since 2013) awarded mainly to projects in selected themes. Researchers from three of the groups (Infection Biology, Bioinformatics, and Tumor Biology) therefore formed the theme Gene Regulatory Systems, to highlight the common approaches used in research on gene regulation in stem cell differentiation, cancer development and fertility. It is mainly these three groups that have received funding from the KF.

It is mostly the Infection Biology, Bioinformatics and Tumor Biology groups that rely on funding from the KF. The other three groups have different funding strategies, which are mentioned in the group summaries below.

Research groups

The centre currently consists of six groups, which are briefly introduced in the following sections.

The **Infection Biology** group currently consists of three associate professors, five assistant professors, three post docs and two PhD students. The group is led by two research leaders who are responsible for the common budget, future plans and for representing the group during managerial meetings in the Systems Biology Research Centre. Currently, the group has eight research projects, where each one is led by a project leader. Thus, it is the project leaders' responsibility to coordinate the research and apply for future funding. The group has a very strong collaboration with the industry and hospitals, making it possible to apply for funding for joint research with the society. The group currently has five grants with five different companies and has recently applied for grants with six new companies. The group members hold unique competences that are attractive for the society as well as international universities. The group also collaborates with a number of Swedish universities and institutes in order to create a strong network for future calls and fund-raising.

The **Bioinformatics** group currently consists of one associated professor, two assistant professors, one post-doctoral researcher and one PhD student. The quality of the research is secured by actively publishing in international peer-reviewed scientific journals. Within the Systems Biology Research Centre, the group has collaborations with the Tumor Biology and Infection Biology groups, which is a way of securing the biological relevance of the bioinformatics research. A typical collaboration project in this context is that a senior bioinformatics researcher takes part in planning the project, including the design of wet-lab experiments, to ensure that the resulting data sets will be suitable for bioinformatic analysis. When recruiting PhD students for these collaborative projects we either select a student with a mixed biology and computational training, or pairs of students where one is more focused on the biology and wet-lab experiments while the other takes main responsibility for doing the bioinformatic analyses and/or implementing algorithms.

The **Tumour Biology** research group comprises two professors, one associate professor, one post doc, four PhD students and one technician. The researchers have biological/biomedicine background specialized in genetics, genomics and tumour biology. The group has long experience in studies of cancer gene regulatory systems through applying a cascade of different molecular genetics methods on chromosomal, DNA, RNA as well as protein levels. The overall objective of the research projects in the group is to identify novel biomarkers for diagnosis, prognosis and/or treatment of different types of disease

conditions in human, with the main focus on cancer. The group has research meetings every second week, where the general status of research is scrutinized, also including seminars about new experimental and analysis methods, and research articles in the group's area of research. In these meetings we also check the status of present funding and make plans for future fund raising.

The **P2T** group was established in 2008 and has grown from four members in 2008 to 12 members in 2012. The group's research is managed by assigning milestones for a research project (e.g. publications, grant applications, conference participations etc.). For each milestone members of the project divide the work (responsibility, objectives, time plan etc.). The milestones are flexible depending on events, and priorities may be altered. Typically a number of tentative milestones are assigned prior to the project and these are in line with the aim of the project. The fund-raising is structured as project management, by assigning a project leader (responsible for applying grants) and a small group of associated project members. The project leader and associated members jointly write the grant applications and submit these to appropriate research councils or foundations for obtaining external grants. A significant part of the research is relevant to developing countries and is therefore funded by the Swedish International Development Cooperation Agency (SIDA) under the framework of the Partner Driven Cooperation (PDC).

The **Ecological modelling** group currently has one professor who is the administrative leader, and three researchers with a PhD. The professor and two of the assistant professors are externally funded to do research 80 – 60 % of full time. The fourth is teaching only. One associate professor is on a leave for a research position at the Swedish University of Agricultural Sciences (SLU). There are three PhD students associated with the group. One is employed by University of Skövde and supervised at SLU, the two others supervised by the senior researchers. The senior researchers take part in national and international research consortiums. Each researcher applies for funding within their partner networks. Researchers from the group recently won a grant from Formas of approximately 7 million SEK over the time period 2013-2015 for the project "Towards sustainable fisheries by ecosystem-based management".

The group **Consciousness and Cognitive Neuroscience** includes one professor, four associate professors, two persons with a PhD and the others have a MS degree. The professors and associate professors are responsible for the main lines of research (Visual consciousness, Altered states of consciousness, Emotions and pain, and Neuroethical and neurocognitive aspects of empathy). The personnel with a MS degree are currently working on their PhD thesis, which are closely associated with the main areas and supervised by either a

professor or an associate professor. We have regular meetings where new research projects as well as the state of on-going projects are evaluated and discussed. All members in the group aim to publish in peer-reviewed scientific journals or congress proceedings, which quality-secures the work rather well since every article has to pass a rigorous evaluation before being published. Research funding is currently focused on The Finnish Academy. The research can be characterised generally as basic research (e.g. theories of consciousness, dreams and hypnosis). Efforts for fund raising have focused on projects that typically include 2-3 researchers and 1-2 PhD students and are aimed to last 4-5 years. Furthermore, there are several foundations in Finland who often provide one-year grants for PhD students and grants from these sources are also continuously applied for. So far we have not actively pursued co-operation with partners from industry but we aim to be more active with this in the future. For example, the research on neuroethical and neurocognitive aspects of empathy has practical implications e.g. in computer gaming and may in provide a possibility for funding from the business sector.

A3.2 Personnel

In 2012 the centre had 41 researchers, which was one person less than the previous all-time-high of 42 in 2009 (Figure 4, based on Table B.1.1.1 and B.1.1.2). In this total has been counted only staff with research time, so in a given year there are usually also some staff who were members of the centre but had only teaching in that year. As the graph indicates, there is a clearly increasing trend for the number of senior staff. This is a result both of upward mobility within the centre and of recruitment. During the evaluation period 2007-2012 there were 20 PhD students who graduated (some of which are now temporary or permanent staff), eight staff who were promoted to become associate professors and four staff who were promoted to become professors (Table B2.1.1). In addition, five recruitments of staff with PhD degrees were made, of which two from outside Sweden and three from other Swedish universities (Table B1.5.1).

The number of PhD students has been decreasing during the evaluation period, from 17 in 2007 to 11 in 2012. At the same time, the staffs that hold PhD degrees have been increasing both in number and in proportion of the total. During the five-year period the number of professors increased from two to five, the number of associate professors from three to seven, and the number of assistant professors from five to eleven. Thus, there was a very strong trend towards more permanent staff and more staff holding PhD degrees (Figure 5).

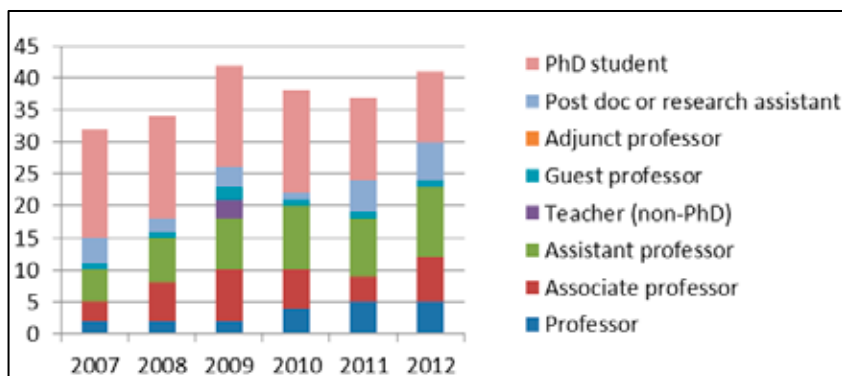


Figure 4. Personnel profile per year during the evaluation period.

The decreasing number of PhD students is likely due to tighter rules for funding of their salaries. All PhD students are employed by the university, but the salary should be paid by external funding. The KF, which we receive most of our external funding from, has recently imposed tighter regulation on using their funding for PhD salaries.



Figure 5. During the evaluation period the percentage of permanent research staff has steadily increased, as has the percentage of staff holding a PhD degree.

A3.3 Infrastructure, facilities and funding

Laboratory facilities

The research centre has access to modern laboratory facilities for education and research. There are five laboratories holding 16 students each for teaching classes in ecology, biomedicine, microbiology, molecular biology and chemistry. There are also two laboratories (for approximately eight students each) for students during their thesis projects.

In addition to the educational lab environment the research centre has four dedicated research labs (for approx. four PhD students each, i.e. 16 in total) for research activities involving biomedicine, mammalian cell culture, pathogens class II and plant biotechnology, respectively.

The laboratories are complemented by several instrument rooms, and rooms for storage of chemicals and labware, which are shared between research and education. These contain equipment for microscopy/fluorescence microscopy, gel electrophoresis/gel documentation, bacterial cell culture, mammalian cell culture, plant cell culture and growing of plants as well as work with radioisotopes.

Laboratory equipment

The laboratories contain instruments for routine laboratory techniques that are used to generate data for research. Cells of bacterial, yeast or mammalian origin are grown in dedicated incubators for studies on their DNA, RNA or protein content. Whole plants can be grown *in vitro* and *in vivo* in a laboratory that has been approved for genetically modified plants.

DNA, RNA and protein can be automatically extracted and purified from cells using a robot (KingFisher) and studied by various techniques. DNA and RNA can be studied by microscopy/fluorescence microscopy and fluorescence *in situ* hybridization (FISH), polymerase chain reaction (PCR), real-time PCR or Pulse Field Gel Electrophoresis (PFGE). Protein and other molecules in the cells can be studied by Western blotting, absorbance/fluorescence/luminescence, fluorescence microscopy, Enzyme Linked Immunosorbant Assay (ELISA) or Radioimmunoassay (RIA).

Laboratory staff

The laboratories are managed by two laboratory assistants and a lab group involving researchers from the different disciplines.

Gothia Science Park

Gothia Science Park (GSP) is a technology and research park with a strong information technology profile. It supports companies and organisations located in the campus area, as well as the surrounding business community. Developmental projects between companies, academia and the community are essential for creating knowledge and competence development that strengthens the companies of the Skövde region, irrespective of industry branch. The university is an important recruitment base for qualified and competent workforce in the form of talented students and market-related research that contributes to product development. Likewise, GSP constitutes an important partner for our researchers and our research environment.

Since the university was chosen as a “KF environment” in 2011, GSP has gradually taken a more active role in supporting collaborations and partnerships between different our research groups and companies. When applications for KF funding are developed, GSP hosts planning meetings where

researchers and company representatives formulate the project goals and milestones with support from the GSP staff. We have found this to be very helpful for formulating co-production plans and identifying the innovation potential of the projects.

A4. Impact, engagement, and co-operation with society

A4.1. Collaboration with society in the UoA

Research groups and individual researchers from the centre are collaborating very actively with society. During the evaluation period the number of industry partners increased from 10 in 2007 to 23 in 2012, while the number of other non-academic partners increased from five to six (Table 3.2.2). The strong collaboration with industry is largely due to our active participation in the KF funding programmes, which require industry co-funding. Thus, the indirect in-kind funding by our industry partners increased from approximately 4 MSEK in 2007 to more than 7 MSEK in 2012 (Table 3.2.4 and Figure 6), while direct research funding from the KF more than tripled, from 1.4 MSEK to 5.4 MSEK. In 2011, the KF funding constituted 64% of our external funding and 31% of our total funding (Table B.1.2.1) (Figure 3).

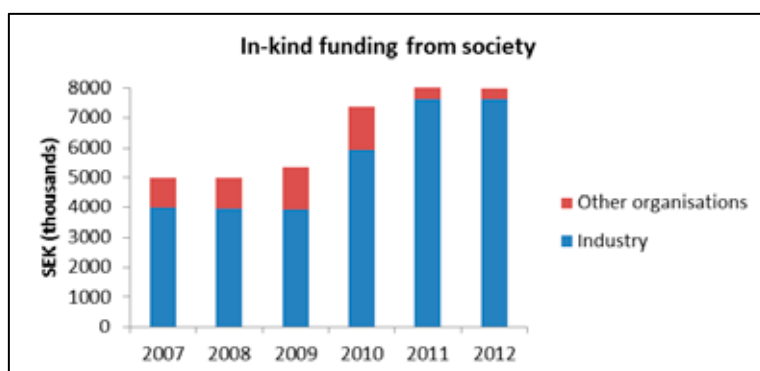


Figure 6. In-kind funding from companies and other organisation during the evaluation period.

The following sections describe examples of currently on-going collaborations with society that we find to be promising. Collaboration with society is also a persistent theme in the two case studies presented in section C, where other examples are described in much more detail.

Spermatozoa microRNA expression signatures for prediction of fetal development in bovine

Research groups: Tumor Biology, Bioinformatics, Infection Biology

Partner from society: Viking Genetics AB

Viking Genetics (VG) is a breeding company that is owned by approximately 30,000 farmers from the Nordic countries. The collaboration was established in 2010 when we granted funding from the KF foundation. The problem addressed is that inseminations with semen from seemingly fertile bulls sometimes result in delayed conception and thereby prolonged calving interval. Consequently, a lower number of calves are produced and there will be a decrease in the annual milk production. Since an individual bull commonly serves many cows, a deficiency in its fertilizing ability has a much larger impact on herd reproduction than the corresponding deficiency of a single cow. As a consequence, low reproduction rates of sub-fertile bulls lead to serious economic losses.

The aim of the collaboration project is to find out how the expression and quantity of sperm-borne miRNAs affect the reproductive quality of mature bovine spermatozoa, and to develop an expression signature based on a few marker miRNAs to be used for prediction of field fertility in bovine of different breeds. A prerequisite for the study was to explore miRNAs in bovine, and consequently we made a survey of the genome organization of miRNAs in bovine. We also carried out an *in silico* identification of sperm miRNAs and their target genes, to identify miRNAs and genes that might be coupled to early developmental stages of the fetuses. The preparation of miRNA from spermatozoa is a challenging and time consuming task, but despite that, we were able to develop a reliable and stable method. We also investigated the presence of not yet detected miRNAs in spermatozoa by NGS on the Illumina platform. The material in this initial study included bull spermatozoa from five brother pairs where one brother has an extremely poor NRR, while the other has excellent results. Preliminary results indicate that a number a new miRNAs will be identified as well as differentially expressed miRNAs between spermatozoa with poor and good NRR. We are currently using QPCRs to study the expression of miRNAs in semen from 30 brother pairs of the Holstein and 30 brothers from the SRB breed made available by VG, including bulls with normal morphology and extremely poor NRR, as well as bulls with excellent results.

We expect to develop a miRNA profile that can differentiate between sub- and superior fertility bulls, alone or in combination with the measurements of semen quality, which are presently used. It would be most beneficial if such a miRNA profile would robustly predict the fertility of bulls independently of breed.

Mathematical models of ulcerative colitis progression

Research group: Infection Biology

Partner from society: InNetics AB

Together with InNetics we have developed mathematical models to quantify a number of parameters that are altered during ulcerative colitis progression. For example, we have shown that the thymic output was reduced in colitic mice compared to the control littermates. We have also participated in the development of PathwayLab, which is an InNetics software tool for modelling and simulation of biological systems. Staff from the centre implemented the systems biology graphical notations (SBGN), which is an emerging standard for graphical notation developed by an international systems biology community. In association to this software we have produced a number of tutorials on how to build and analyze complex mathematical models. These tutorials have, for example, been used by students on undergraduate courses.

Markers for early recognition of sepsis

Research group: Infection Biology

Partner from society: Unilabs AB, bioMérieux Sweden AB and Skaraborg Hospital

In collaboration between academy, industry and hospital, we are currently involved in two projects concerning diagnosis of sepsis patients. In the first project, we aim to assess the usefulness of several novel molecular diagnostic tests for identifying pathogens in patient specimens, whereas the second project focuses on the development of a multimarker panel for earlier recognition of sepsis by using computational approaches. Each partner contributes with its unique competence; members from the infection biology research group possess the competence in mathematical/ computational modeling and infection biology, the industry (i.e., Unilabs AB and bioMérieux Sweden AB) have experience of routine diagnostics as well as product development, and the physicians at Skaraborg Hospital provide the clinical knowledge. We have so far optimized and evaluated several commercial molecular diagnostic methods for pathogen detection to enable a faster and more accurate detection of patients with sepsis. In consultation with the hospital and the university, Unilabs AB will decide whether to implement any of the tests in the routine diagnostics for pathogen detection in blood specimens from patients suspected with sepsis.

A4.2 External collaborations and contributions that support the research within the UoA

The **Infection Biology** group has, in collaboration with the Hultgren-Hörnquist lab (Örebro University) and the Davis lab (University of Oxford), access to facilities such as FACS, MACS, SPR, NMR, as well as animal models and patient samples. The group also collaborates with Unilabs AB and Skaraborg Hospital in a study on sepsis where the partners provide access to clinical data, biobank

specimens and equipment such as MALDI-TOF MS and pipetting robots. Through their collaboration with Collectis, the group also has access to facilities for culturing of pluripotent stem cells in specially equipped stem cell laboratories.

The **Tumor Biology** and **Bioinformatics** groups jointly have close collaborations with bioscience companies (TATAA Biocenter, VWR International, Viking Genetics, MultiD) that give access to facilities and advanced equipment. For example, the large-scale QPCR experiments in on-going projects are performed at TATAA Biocenter and the collection of sperm samples for projects on bull fertility is performed at VikingGenetics' facilities. Through collaborations with researchers at Göteborg University, including Sahlgrenska Academy's Cancer Center, the group also gets access to research instruments and facilities, including core facilities at the Sahlgrenska Academy. This includes the Centre for Cellular Imaging (CCI), Centre for Physiology and Bio-Imaging (CPI), Genomics Laboratory for Experimental Biomedicine (EBM), Mammalian Protein Expression (MPE), Proteomics, and Bioinformatics.

The **P2T** group collaborates with a group at the Swedish University of Agriculture (SLU), sharing not only advanced equipment such as Mass-Spec, EM, DNA-sequencing, but also PhD students and projects leading to several joint publications. In a shared PhD project with University of Örebro, they identify novel bacterial strains based on Mass-Spec and EM analyses performed at Örebro's facilities. They have also established collaboration with the Plant Breeding and Genetics group at the University of Agriculture in Krakow, Poland. Genetically modified plants developed in Skövde are analysed by the group in Krakow based on greenhouse trials and microscopic observations.

The group **Consciousness and Cognitive Neuroscience** collaborates with the Center for Cognitive Neuroscience, University of Turku, and with the PET Center, University of Turku. Through these collaborations, the group has access to the following facilities and laboratories: EEG, TMS, PET, fMRI, eye-movement lab, and experimental psychology labs.

Members of the **Ecological Modelling** group have access to computational facilities at Linköping University.

A4.3 Innovation activities

Together with the partner company InNetics, the **Infection Biology** group has developed new modules for user-friendly software (PathwayLab) for modeling and simulation of biological systems. The software has, for example, been used in undergraduate courses in immunology and biochemistry where the students learn to understand the dynamics of biological systems.

In collaboration with UniLabs AB and Skaraborg Hospital, the Infection Biology group also optimized and evaluated several commercial molecular diagnostic methods for pathogen detection to enable a faster and more accurate detection of patients with sepsis. The included molecular assays (Prove-it Sepsis™, Magicplex™, QuickFISH™, and SepsiTyper™) were assessed with respect to various parameters such as clinical sensitivity, specificity, predictive values, accuracy, turn-around-time, costs, clinical usefulness, etc. Based on our results and evaluation, UniLabs will decide whether to implement any of the tests in the routine diagnostics for pathogen detection in blood specimens from patients suspected with sepsis.

A researcher from the Infection Biology group was also, together with Collectis AB, granted two patents on stem cell derived products. The first one covers clusters of cardiomyocytes derived from human embryonic stem cells (hESC). The cluster format resembles the structural organization of cells in a real organ, and mimics *in vivo* cell signaling. The second patent covers the use of specific microRNA as biomarkers for detection and isolation of hESC-derived cardiomyocytes.

Sartipy P, Åkesson K, Améen C, Dahlenborg K, Synnergren J, Steel D “Cardiomyocyte-like cell clusters derived from hES cells”. WO2009036982, 26 March 2009.

Sartipy P, Synnergren J. “Novel microRNAs for the detection and isolation of human embryonic stem cell- derived cardiac cell types.” WO2011EP59785, 14 June 2011.

Researchers from the **P2T** group (Sandra Karlsson and Dennis Larsson) founded the company Nordic BioPharma in 2009. Nordic BioPharma provides valuable services for companies and academic organizations involved in chemical industry, medical devices, drug development, cosmetics and cell sciences. One of its main focuses is preclinical immune safety testing without the use of animals. Nordic BioPharma offers highly accurate and sensitive population based immunogenicity methods including both *in silico* and *in vitro* methods for immunogenicity assessment, T-cell epitope discovery methods, proliferation assays and specific-immune activation assays.

The group **Ecological Modeling** has developed new methods for calculating fisheries quota for herring and sprat in the Baltic Sea. The model developed in the project has been used by the International council for the Exploration of the Seas to set reference points on maximum sustainable yields for herring in the central Baltic Sea and sprat in the central Baltic Sea for 2011 (ICES 2011). In 2012 it was used to set quota for herring in Bothnian Sea (ICES 2012).

Researchers from the **Bioinformatics** group were co-founders of the biotech company CropTailor AB in 2007, where the initial impetus of the company was our EST sequencing project which identified more than 2,000 novel oat genes

(Bräutigam et al., 2005). CropTailor is a plant biotech company that develops new oat varieties using high precision methods, such as TILLING. This makes it possible to increase the variation in the breeding material compared to traditional breeding, while avoiding that the developed oat lines will not be defined as GMOs, which greatly simplifies their commercialization.

A5. Self-assessment and future development

SWOT ANALYSIS – STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

Based on the quantitative data in section B and the qualitative description of in section A, we have identified a number of strengths and weaknesses of the centre. In addition, when looking at external factors, the environment that the centre is working within, we can see both opportunities and threats to the continued development of the centre.

Strengths

A broad range of competences. The researchers in the centre have expertise in a broad range of experimental methods and mathematical and computational approaches. This provides a strong platform of knowledge and competences, which makes the centre an attractive and dynamic environment to work in. Our collective knowledge in various systems biology approaches is the main reason why the industry is keen to collaborate with the centre, since the companies usually do not hold such competences. Most of the collaborations with companies involve analysis of experimental data produced by our partner companies. Therefore, these co-productive projects are dependent on our knowledge in systems biology approaches. Our knowledge in systems biology has also attracted hospitals and other universities to collaborate with the centre. Hence, through our specialized competences, we have over the past years created a strong research network that enables us to continue to increase our funding capacity.

An organization that supports interdisciplinary research. Over the past few years, the organization of the centre has become stronger and includes more joint activities. Several members of the centre have been involved in interdisciplinary projects spanning over different research groups. Individual researchers have also shifted from one research group to another. Thus, the competences within the center have been mixed in different constellations, and new projects have been identified. Members from three different research groups have recently developed the Gene Regulatory Systems theme. Although studies of different types of cells are applied (e.g. cancer cells, immune cells, stem cells etc), the approaches to study gene regulatory systems are virtually

the same. For example, knowledge from mathematical or computational models and tools to study intracellular pathway can be shared in the theme. There is an ongoing effort to create additional common research themes, in which researchers from different groups will collaborate towards long-term goals.

Highly active collaboration with society. Many of our research projects are collaborations with companies and other organizations. In particular, the collaborations with industry are well established. During the evaluation period the number of partner companies doubled. The collaborations represent true co-production since in addition to the scientific results achieved, the collaborations have led to: new patents, inventions that are commercialized by the companies, and formation of new companies. The collaboration with society also includes other organizations, such as hospitals and government councils. Thus, the research clearly has an impact on society, both commercially and in terms of improvements in health care systems and environmental policies.

A strong publication profile. Our results are predominately published in international peer-reviewed scientific journals. The impact of the journals in which we publish is higher than the average for our field, and our articles are frequently cited by peers in the field. In relation to our resources, and taking into account that we work at a small and newly established university, our number of publications per year is high. We are also actively participating in our research communities as reviewers, editors and invited speakers at scientific conferences.

Development of competence. Members of the research centre tend to do well in developing their competence over time. Our PhD students generally succeed in finishing their theses and graduate, despite the fact that we do not have the rights to award PhD degrees. We have a good record of assistant professors being promoted to associate professors, and associated professors being promoted to professors. The number of senior researchers in the centre doubled during the evaluation period.

Weaknesses

Limited of success in gaining funding from research councils or the EU. The total amount of funding from research councils, such as *Vetenskapsrådet* (The Swedish Research Council) or Formas, as well as from the EU, has been very limited during the evaluation period. Recently, however researchers from the Ecological Modelling group won a grant from Formas of approximately 7 million SEK over the time period 2013-2015 for the project “Towards sustainable fisheries by ecosystem-based management”.

No rights to award PhD degrees. An inherent drawback of being a small university is the limited possibility of offering PhD courses and awarding PhD degrees. Currently, the university has PhD examination rights only for Information Technology. The lack of rights to examine PhD students in systems biology complicates the recruitment process, since the students must be enrolled at other universities. In addition, the university currently prioritizes funding of new PhD students in information technology, in an effort to build up a research school in that subject.

Lack of funding for PhD students. The centre has been very successful with funding from the KF, but according to new regulations KF funding is nowadays mainly intended for senior researchers and postdocs. As a result, we have not been able to finance enough PhD students although the total external funding has increased. As a result, the number of PhD students actually decreased during the evaluation period, from 17 in 2007 to 11 in 2012.

Lack of independence and formal influence. The centre is approved and supported by the university, but it is not a separate unit of organization. It consists of sex research groups, each one with its own budget, which is dependent on the individual researchers' success in applying for funding for their projects. Apart from a small grant of 0.5 million SEK per year, the centre does not have any budget at its disposal, and therefore no financial independence. The total research spending of approximately 18 million SEK per is the sum of the individual groups' budgets. The centre is not a separate unit of organization, as all researchers are employed by departments and have their primary affiliation with a particular subject of teaching. This means that the centre itself cannot, for example, recruit staff. Since the centre is so "embedded" in the organizational structure of the university, it is highly dependent on decisions made by the departments, which can make it difficult to work systematically towards a long-term vision and research strategy.

Opportunities

Systems biology is a rapidly evolving research area. Due to the increasing demand of competences in systems biology our competence is likely to continue to attract new collaborations. It is a fruitful area of research for multi-disciplinary collaborations.

Collaboration networks provide opportunities for applications for EU funding. A number of new companies that we have started to collaborate with are currently involved in different EU projects. Thus, there is now a great opportunity for the centre to connect to new EU networks.

The Gothia Science Park. The university has a very active science park with offices in the same building as the centre and with a mission to support development of collaborations with industry.

Threats

Too much applied research. The research may turn too much into development projects rather than research, due to too the extensive collaboration with industry. There is a risk that we fail to keep a good balance between basic and applied research.

Internal funding drying up because of a lack of students. Since all researchers also are teachers, the recruitment of permanent staff requires a solid recruitment of students to our undergraduate programmes in biology. Hence, in order to grow in permanent staff, we need to increase the number of students at undergraduate and master levels. According to demographic forecasts, the Swedish student population will be shrinking in the next few years. Additionally, the interest among young people in studying biology and life sciences may also be decreasing. We have many study programmes given in English, but the possibilities of recruiting foreign students are rather sensitive to changes in economic trends, fee systems, and other factors.

Difficulties in recruitment of permanent staff. The possibilities of recruiting permanent staff are dependent on many factors: the attractiveness of the centre as a working place, the number of students, the degree of success in securing external funding, etc. It can also be very difficult for junior researchers to get permanent positions. A possible threat is that the university becomes too defensive in its employment strategy. Too high requirements on funding already being in place before a hiring decision is made can result in promising junior researchers becoming disillusioned about the future prospects and leaving the university.

GRADING OF ABILITIES

Ability to recruit qualified staff and PhD students

Grade: 5

Track record: The centre has been successful in increasing both the number of staff and the qualifications of the staff. On the other hand, the number of PhD students has been decreasing (Figure 7).

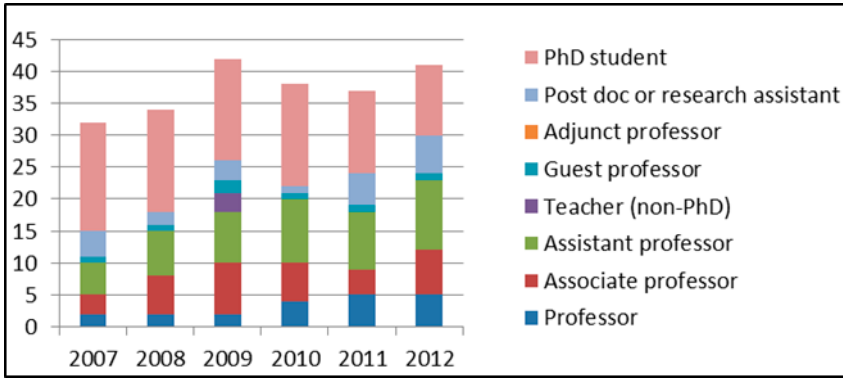


Figure 7. Number of staff and PhD students per year.

Outlook: We see good opportunities for attracting both PhD students and new staff to join the centre. The research area is attractive, interesting and rapidly evolving. When we have PhD student places or staff positions to offer, there is usually no difficulty in filling these positions. However, the limiting factor seems to be funding. It has gradually become more difficult to gain funding PhD students. Funding agencies have become less willing to fund PhD student salaries and it has also become more difficult to find internal university funding for PhD students. The most promising possibility we see is to apply for the rights to award PhD degrees, and thereafter apply for funding for a research school in applied systems biology. The KF has such a funding programme, and we have a wide range of partner companies that might co-fund the research school. We therefore plan to apply for examination rights in the next year.

The ability to gain internal funding for recruitment of permanent staff is largely dependent on the number of students at bachelor and master's level. The department is currently focusing on the issue of student recruitment, but it may be difficult to raise the number of students to such high levels that it would have a decisive impact on the funding situation for permanent staff. It will therefore be important to increase our levels of external funding even more in the future. This may be needed even to just maintain the current number of senior researchers.

Ability to attract external research funding

Grade: 6

Track record: The centre has been very successful in attracting external funding from agencies such as the Knowledge Foundation, SIDA and FORMAS. However, the centre needs to increase its funding from EU. From 2007 to 2011 the external funding almost doubled, while at the same time the dependency on Swedish foundations increased (Figure 8).

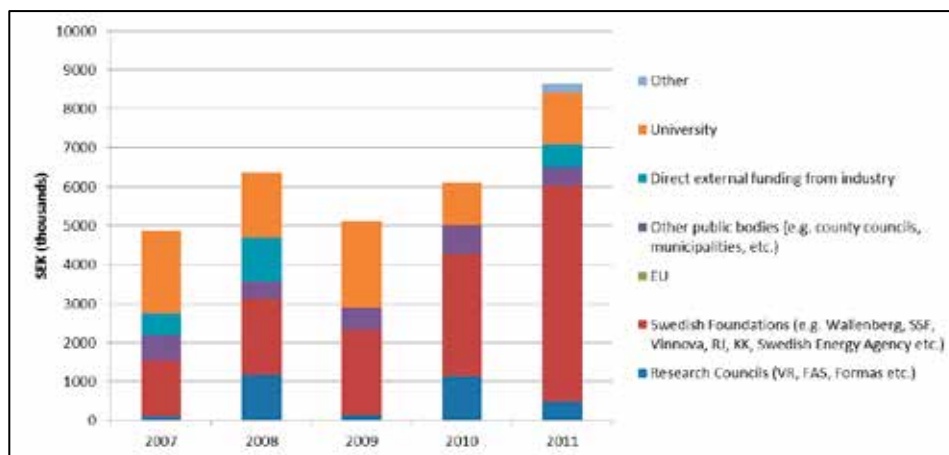


Figure 8. External funding per year and type of source.

Outlook: It should be possible to increase the amount of funding from the KF even further in the coming years. During the evaluation period we have gained valuable experience in setting up co-production projects and balancing the academic goals of the researchers with the business goals of the companies. By selecting University of Skövde as a “KF environment” the foundation has clearly signaled that it wants to have an active role in the development of our research environment.

At the same time, we do have a need of diversifying our funding sources. The groups will have to work more systematically towards grants from the EU, the Swedish Research Council, etc. One advantage of being a heterogeneous center with a diverse set of research groups is that we can learn from, and support, each other. The Ecological Modelling group have succeeded in getting funding from Formas, the Consciousness and Cognitive Neuroscience group has been successful with applications to the Academy of Finland, and the P2T group has a lot of experience from the SIDA programmes (Table B1.3.2). There are, in other words, many opportunities, both for joining forces and applying together, and for learning from each other how to plan suitable projects for each form of funding. This is something we need to work with more systematically and strategically.

Ability to position the UoA internationally

Grade 4.

Track record: Members of the centre continuously participate in international conferences, publish in peer-reviewed journals, and have collaborations with international universities. However, the centre participates relatively little in EU-funded projects. There are several examples of research undertaken in

international collaboration in projects (Arsenic uptake together with developing countries, fisheries within ICES, husbandry disease protection etc). The statistics in Table B1.3.1 reflect the scope of the international collaboration networks. A comparison of the number of publications and the author fractionalized number of publications (Table B2.2.2) shows that we published together with collaboration partners to a very high degree (Figure 9). The fact that these collaborations are often international is reflected in the average number of countries per publication, based on the affiliations of the authors (Table B2.2.4 and Figure 10). These figures show that the individual researchers and groups have extensive collaboration networks. However, the centre as a whole is not particularly recognized, since it has not, as one unit, received any large-scale grant and has no participation in any major systems biology network.

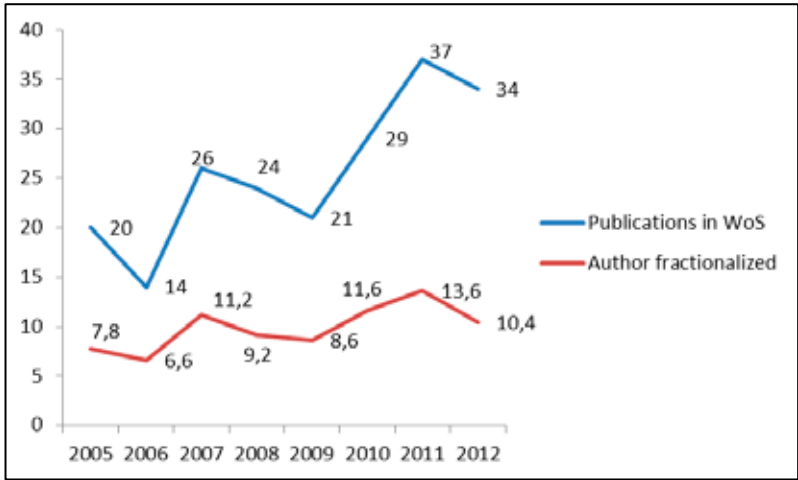


Figure 9. Comparison of number of publications (blue) and number of author fractionalized publications (red). The difference represents the contributions from collaboration partners.

Outlook: There is a choice of strategies for further development of the centre in terms of international recognition. The current groups are successful in their respective fields, but constitute a fairly loose collection of research orientations. There is nothing wrong with this, and the future strategy may be to continue in the same direction. The label “systems biology” is then used mainly to indicate a common interest in collaboration between the groups. When following this strategy, it may be better to rename the centre to a more neutral term, such as “biological systems”, or even “life science”, to better reflect the diversity of the groups. The ability to place the centre internationally will then continue to be a matter of each group striving for international recognition in their respective fields.

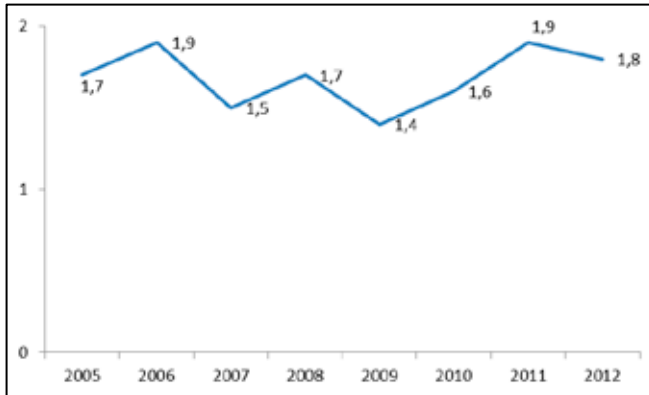


Figure 10. Average number of countries per publication, based on author affiliations.

Another strategy would be to develop a small number of common research themes. Researchers from three of the groups recently established the theme “Gene Regulatory Systems” in an attempt to strengthen their collaboration and work together towards a more recognized position. Efforts to formulate a second research theme are ongoing, but it may be difficult to capture the specializations of all researchers within two-three clearly defined themes.

A third strategy would be to strive towards a more specialized centre, where all research would focus on mathematical modelling, simulation, and other “pure” systems biology methods. In such a specialized centre the majority of results would be published in systems biology journals or presented at systems biology conferences. It is, however, difficult to see how this could be achieved without a major restructuring, which would not only include recruitment of internationally recognized high-profile professors of systems biology, but also losing a lot of the current competences which would not fit into this plan. It is unlikely that such a strategy would be considered feasible and desirable.

Part B: Quantitative data

In this part of the evaluation package questions and tables are presented in 3 sections which contain quantifiable information about the UoA in support of the statements made in Part A above.

B1: Research environment and infrastructure

B2: Research output

B3: Impact, engagement and co-operation with society

B1. Research environment and infrastructure

B1.1 Staff statistics

Provide information of the number of individuals and full time equivalents (FTE) of staffs' research activity. The 'M' columns show values for men and 'W' for women. The number of individuals refers to Dec 31st each year, whereas FTE is integrated over the whole year. FTE is only presented for 2011 and 2012.

Table B1.1.1. Number of and full time equivalents of permanent research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Professor	1	1	1	1	1	1	3	1	3	2	3	2
FTE									1	0.2	1.3	0.5
Assoc. prof. (Lektor and docent)	3		6		8		5	1	4		7	
FTE									0.8		2.7	
Assist. prof. (Lektor, forskare)	5		5	2	6	2	4	6	5	4	4	7
FTE									0.8	1.4	0.7	1.3
Lecturer (Adjunkt)					3							
FTE												
Total Individuals	9	1	12	3	18	3	12	8	12	6	14	9
Total FTE									2.6	1.6	4.7	1.8

¹ Professor denotes persons employed as full professors. Associate professor denotes staff qualified to act as principal advisor for PhD students (docent appointment or similar). Assistant professors denote the rest of staff with a PhD.

Table B1.1.2. Number of and full time equivalents of temporary research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Guest profs	1		1		1	1		1		1		1
FTE										1		0.2
Adjunct profs												
FTE												
Assistant professor												
FTE												
Post-Docs and research assistants	1	3	1	1		3		1	1	4	1	5
FTE									1	2.4	0.2	3.6
PhD students ¹	6	11	4	12	2	14	3	13	3	10	4	7
FTE									2.2	6.5	2.8	7.4
Total individuals	7	14	6	13	3	18	3	15	4	16	5	13
Total FTE									3.2	8.9	3	11

¹ All temporary employed admitted to PhD studies

Table B1.1.3. Other staff supporting research in UoA												
Year	2007		2008		2009		2010		2011		2012	
Staff	M	W	M	W	M	W	M	W	M	W	M	W
Research assistant/ Technician												
FTE												
Administrator						1		1				
FTE												
Total individuals						1		1				
Total FTE												

¹ Fixed term and visiting research staff. Staff is included in the research output as well as in the bibliometric analysis.

B1.2 Research funding

Sources of research funding and amounts given to the UoA annually during 2007-2012.

Table B.1.2.1. External funding (spent money in t SEK)						
	2007	2008	2009	2010	2011	2012
Research Councils (VR, FAS, Formas etc.)	110	1165	144	1139	476	

Swedish Foundations (e.g. Wallenberg, SSF, Vinnova, RJ, KK, Swedish Energy Agency etc.)	1420	1948	2175	3141	5547	5388
EU						
Other public bodies (e.g. county councils, municipalities, etc.)	652	438	591	739	487	
Direct external funding from industry.	553	1150			594	911
University	2146	1662	2206	1076	1298	2585
Others (please specify) foreign organization without profits motives					240	
TOTAL	4881	6363	5116	6095	8642	8884

Table B.1.2.2. Total Research Funding t SEK						
	2007	2008	2009	2010	2011	2012
Total external funding (from table B.1.2.1.)	4881	6363	5116	6095	8642	8884
Faculty funding (governmental funding)	6798	7160	8054	9253	7256	9209
Percentage external funding	42	47	39	40	54	49
Research as competence development	1413	4518	5411	2727	2243	1870
TOTAL	13092	18041	18581	18075	18141	19963

B1.3 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during **2011-2012** by permanent research staff.

Table B1.3.1 International networks and collaborations	
Number of collaboration institutions ¹	74
Number of research visits abroad (1 week to 1 month duration)	34
Number of research visits abroad (of at least 1 month duration)	2
Number of visiting researchers (1 week to 1 month duration)	13
Number of visiting researchers (of at least 1 month duration)	1
Number of funded international research consortia projects	8

¹ Research collaborations given here are limited to those with joint research grants in excess of 100kSEK/year and/or joint publications with the UoA.

B1.3.2 Name of project granted and role of UoA			
Project title	Funding body	Role (coordinator/partner)	Start year
Circulating Tumour Cells and prostate cancer outcome	Mitacs - Accelerate Graduate Research Internship Program	Main supervisor for the PhD student, Julius Adebayo Awe, who received the internship	2012
NGF, touch, pain	Vetenskapsrådet	Coordinator	2010
Neuroscience of brain reading	Academy of Finland	Partner	2009
Spread of animal diseases within US livestock	DHS	Partner	2010
IBAM	FORMAS, BONUS+	Partner	2009
Bioremediation of toxic metals and other pollutants for protecting human health and the ecosystem	SIDA	Coordinator	2010
An eco-friendly approach for protecting human health and the environment from toxic wastes disposed from oil refinery industries	SIDA	Partner	2012
Identifying novel biomarkers of COPD and design of innovative preventive and therapeutic strategies targeted for the benefit of Indian population	SIDA	Coordinator	2012

B1.3.3 Other major international activities according to the tradition of the research field¹	Total No.

¹ Please specify: scientific expeditions, field work etc. and list below including duration
A maximum of five examples in total may be provided.

B1.4. Participation in scientific community

UoAs activities undertaken during 2007-2012 that illustrate high quality leadership interactions with their scientific peers.

B1.4.1 Participation in academic community	Number
Plenary or keynote talk at international conferences	14
Assignment as expert in research councils and foundations	16
Assignment as expert evaluator for position as professor, associate professor (docent) and lecturer	3
Assignment as opponent for PhD thesis	2
Assignment as member of examination board for PhD thesis	28
Assignment as editor or member of editorial board for journal	14
Assignment as reviewer for international journal	226
Member of national scientific councils	2
Member of international scientific councils	5
Chair of program committee (international conferences)	4
Member of program committee (international conferences)	16

B1.5 Recruitments

Number of recruited research staff, men (M) and women (W) during 2007-2012.

B1.5.1 Recruitments	Number	
	M	W
Recruitments with doctoral degree from another Swedish university	2	1
Recruitments with a doctoral degree from outside Sweden	2	
Recruitment with doctoral degree from own university		
TOTAL	4	1

B2. Research Output

B2.1 Promotions and degrees

This section quantifies the development of scientific staff during 2007 to 2012 distinguishing men (M) and women (W).

B2.1.1. Doctoral degrees awarded and promotion of researchers												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
No. Doctoral degrees	2		1	5	2		2	2		1		5
No. Docent promotions	3	1	2						1		1	

No. Professor promotions	1						2			1		
TOTAL	6	1	3	5	2		4	2	1	2	1	5

B2.2 Publications

Publications and other research output achieved during 2005-2012 to provide the publication profile of the UoA.

Table B2.2.1: Total number of scientific publications produced by the UoA. Please specify citation index in each publication list.

Publication types	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Article in journal, peer reviewed	23	12	29	27	20	34	40	35	220	27.5
Article in journal, not peer reviewed	1	2	1		1	1		1	7	0.9
Article in journal, book review										
Article in journal, review				1	3	3	2		9	1.1
Book		2		1	1	1			5	0.6
Edited book										
Chapter in book	3		3		2	3	3	4	18	2.3
Conference paper (peer reviewed)	5	4	5	3		2	3	2	24	3.0

Conference paper (not peer reviewed)	1	6		1					8	1.0
Thesis, doctoral	1	2		2	2	3		4	14	1.8
Thesis, licentiate ¹		2				1		1	4	0.5
Thesis, master	-	-	-	-	-	-	-	-	-	-
Report	2	3			1	1	1	2	10	1.3
Other scientific publication	-	-	-	-	-	-	-	-	-	-

¹ Licentiate is a Swedish and Finnish academic degree on graduate level corresponding to circa half a Swedish PhD.

Table B2.2.2. Aggregate publication information

	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Total number of publications in DiVA	36	33	38	35	30	49	49	49	319	39.9
Number of publications in Web of Science	20	14	26	24	21	29	37	34	205	25.6
Number of publications in Web of Science, author fractionalized	7.8	6.6	11.2	9.2	8.6	11.6	13.6	10.4	79.1	9.9

Web of Science visibility (percent of publications included)	56%	42%	68%	69%	70%	59%	76%	69%	64%	-
Scopus visibility (percent of publications included)	58%	39%	74%	83%	73%	63%	86%	55%	67%	-
Journals' field normalized impact	1.05	3.71	1.13	0.9	0.79	0.87	1.02	-	1.11	-
Journal Impact Factor	4.58	2.71	3.33	2.76	2.3	3.23	3.36	-	3.21	-
Norwegian score	40.1	31.1	46.4	34.4	31.4	53.8	65.4	47.8	350.4	43.8
Norwegian score fractiona-lized	16	20.4	21	13.2	14.6	24.4	23.1	13.7	146.4	18.3
Publica-tions in level 1 journal – Norwegian list	16	11	20	25	18	24	29	27	170	21.3
Publica-tions in level 2 journal – Norwegian list	7	1	7	2	4	7	11	6	45	5.6
Publica-tions in level 1 conference – Norwegian list	2	5	4	4		2	3	1	21	2.6

Publications in level 2 conference – Norwegian list										
Publications in level 1 book publishers	1	1	1		2	3	1	3	12	1.5
Publications in level 2 book publishers	1	1	1			1			4	0.5

Table B2.2.3. Citation indicators

	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Total number of citations	315	203	247	248	124	127	145	-	1409
Number of citations, author fractiona-lized	114.6	48.7	88.8	76.4	42.4	44.2	38.6	-	453.7
Citations per publication	15.8	14.5	9.5	10.3	5.9	4.4	3.9	-	8.2
Share of publica-tions not cited	20%	36%	8%	4%	10%	10%	16%	-	13%
Average field normalized citation rate	0.59	0.99	0.62	0.72	0.77	0.54	1.05	-	0.76

Share of publica- tions among the 10 percent most cited in the field	0%	10%	5%	0%	5%	3%	6%	-	4%
Share of publica- tions among the 25 percent most cited in the field	13%	20%	14%	14%	25%	3%	28%	-	17%

Table B2.2.4. Authorship									
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Average authors per publica- tion	5.2	5.6	5.3	4.6	5.1	5.8	5.7	6	5.5
Average countries per publica- tion	1.7	1.9	1.5	1.7	1.4	1.6	1.9	1.8	1.7

Table B2.2.5. Role of key scholars									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Share of publica- tions by 3 most active authors	42%	45%	47%	57%	43%	39%	29%	18%	39%

Table B2.2.6. Productivity

	2007	2008	2009	2010	2011	2012	Total	Annual average
Number of publications in relation to total funding (MSEK).	2.90	1.94	1.61	2.71	2.70	2.45	2.36	2.39
Number of publications in relation to FTEs					3.01	2.39	2.66	2.70
Number of citations in relation to FTEs					8.90	0.00	3.94	4.45

B2.3 Innovation output

As well as engaging with society through contract research or education, researchers today sometimes patent their findings, commercializing these through multiple routes. Researchers also form companies either based on patents, or other forms of intellectual property e.g. materials, software or experience. These activities, often referred to as 'innovation activities', are listed in the tables below for the years 2007-2012.

B2.3.1. Patents¹			
Patent number ²	Short description	Person(s) involved at UoA	Date of registration
WO2009036982	Cardiomyocyte-like cell clusters derived from hBS cells	Jane Synnergren	2009-03-26
WO2011EP59785	Novel microRNAs for the detection and isolation of human embryonic stem cell- derived cardiac cell types.	Jane Synnergren	2011-06-14

¹ Data should match that held in DiVA.

² Awarded patents only, not patent applications.

B2.3.2. Founded companies¹				
Company name	Founder(s) from the UoA	Company type	Date of formation	Current status
Nordic BioPharma AB	Dennis Larsson, Sandra	Life Sciences	2009-05-31	Growing

	Karlsson, Dan Lundh			
CropTailor	Angelica Lindlöf, Björn Olsson	AB	2007-01-09	Active

¹ Included eligible companies must be a direct result of the university's research activities and have, or have had, an annual income in excess of 100 kSEK.

B3. Impact, engagement and co-operation in research with society

This section presents activities related to co-operation in research with society and the impact of such activities. It includes the unit's general approach to enable impact and engagement from its research, and also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B3.1 PhD degrees

The number of doctoral degrees (PhD, etc.) earned within the UoA during 2007-2012 when the awardee has been externally employed. Number of men ('M') and number of women ('W') are recorded per year.

Table B3.1.1. Doctoral degrees awarded to students externally employed												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
Number of doctoral degrees	0	0	0	1	1	0	0	0	0	0	0	0

B3.2 Major research related co-operation with society

Activities regarding research related co-operation with society should be entered into one of three categories in the table below: Table 3.2.1 lists mobility between academia and non-academic society, such as exchanged lectures with external (non-academic) organisations, the engagement of adjunct professors, and externally financed PhD students in collaborative research projects with partners from industry or other organisations in society; Table 3.2.2 includes the number of publications co-authored with individuals outside of academic institutions, and popular publications aiming at the general public; Table 3.2.3 counts the number of external partners of the UoA separated between SME, large enterprises, and non-industrial partners; Table 3.2.4 summarizes the amount of *in kind* funding from industry and non-industrial organisations in society.

Table 3.2.1: Mobility between academy and society						
	2007	2008	2009	2010	2011	2012
No. of collaborative doctoral students ¹	0	0	0	0	0	1
No. of temporary research positions outside university ²	0	0	0	2	2	2
No. of adjunct researchers	0	1	1	1	0	0

¹Number of doctoral students in the UoA who are financed by non-academic external partners. Note that this does not mean doctoral students who are financed by any non-academic funding body, but students who are financed by external partners to the UoA (e.g. industry or public sector organisations).

²Permanent UoA personnel who migrate from the university to non-academic society

Table 3.2.2: Outreach activities						
	2007	2008	2009	2010	2011	2012
No. of scientific publications with representatives from society (not academia)	6	8	6	10	5	9
No. of popular science publications (popular science magazines, including the internet)	5	8	4	4	9	5

Table 3.2.3: Collaboration organizations (please provide description in A4.1.)						
	2007	2008	2009	2010	2011	2012
No. of partners from industry (SME) ¹	10	8	9	15	19	22
No. of partners from industry (non SME)	0	0	1	1	1	1
No. of partners from society excl. industry and academia	5	6	8	9	9	6

¹enterprise with no more than 250 employee and an annual turnover not exceeding 50 M €.

Table 3.2.4: Indirect external funding (in t SEK)						
	2007	2008	2009	2010	2011	2012
Indirect funding from non-industrial organisations in society (in kind ¹)	1005	1005	1405	1455	355	355
Indirect external funding from industry (in kind)	3977	3961	3935	4800	6520	6505

¹value of working hours done by external partner, value of equipment, databases, software, laboratories etc. that external partners provide in joint research projects.

Part C: Case descriptions

Table C1.1.2 Template for impact cases (maximum 4 pages)

Title of case 1: **Understanding the differentiation of human pluripotent stem cells**

The overall aim of this research project is to increase our understanding of the regulatory mechanisms that control the fate of stem cells. Human embryonic stem cells (hESCs) have unique properties of proliferation and self-renewal, and can be differentiated into various functional cell types e.g. hepatocytes and cardiomyocytes. Based on these properties hESCs have potential to fulfill an urgent need from the pharmaceutical industry for *in vitro* model systems with high human relevance that can be used for toxicity testing, drug development, and disease modelling. Today, animal models, primary cells, or cell lines with limited responsiveness are used, but these systems have many limitations and results from them are difficult to extrapolate to the real situation in humans. This is exemplified by the fact that toxic effects of novel candidate compounds are sometimes not detected until very late in the drug development process. Considering the costs associated with drug development, there are billions of dollars to be saved by reducing late stage attrition in the pharmaceutical industry. Besides the economical considerations, improved test systems will likely contribute to increase the safety aspects in drug development and reduce unwanted side-effects. Moreover, *in vitro* model systems will also have positive effects from ethical points of view, as they have potential to replace a large amount of the animal experiments that are performed today.

With the above in mind, this project focuses on a number of challenges associated with current stem cell technology which limit the general and widespread industrial implementation of novel *in vitro* based models. The research has included extensive characterization of the stem cell derivatives, verification of human relevance, and benchmarking to conventional models. The project started in 2005 and is still ongoing today. The main industrial partner since the start of the project has been Collectis AB (previously called Cellartis AB) and funding has come from several different grants, with the Knowledge Foundation as the main source. The project has made significant contributions to the development of several commercial stem cell products at Collectis, with the first one being launched in 2008. Since then several products consisting of differentiated cardiomyocytes and hepatocytes distributed as plates of functional cells have been developed. These products are used as *in vitro* screening systems by companies from the pharmaceutical industry as well as by research institutes world-wide. There are also on-going product development projects with intended clinical applications of functional cells, so we foresee that products for cell therapies will also be available in the

future. Researchers at the university have contributed with extensive transcriptional characterization of all the cell-products that have been commercialized and these are now being distributed to customers in many parts of Europe and USA. The products have also made a noteworthy success in Japan, where Eisai Co. Ltd. and the Tokyo Dental and Medical University are examples of customers that routinely buy cardiomyocyte products (hES-CMC™) from Collectis for use in their toxicity testing systems. Moreover, Vala Sciences in the USA use hES-CMC™ for toxicity screens.

Results from this research have made important contributions within the area of drug development and toxicity testing by development of *in vitro* systems for large-scale screening of different compounds. By the advent of this technology large-scale toxicity screens based on human cells can be applied early in the drug development processes, and candidate drugs that indicate toxic response during the screens can be eliminated at an early stage. This has resulted in a reduction of the number of promising drug candidates, so that wasting resources can be avoided.

Besides the pharmaceutical industry, the need for alternative toxicity testing methods is pressing also in the chemical and cosmetic industries. This is extremely urgent since the European Union has since 2013 banned the sale of all new cosmetics that have been tested on animals. On the other hand the European REACH initiative requires toxicity testing of all chemical substances that are used by humans. With this in mind scalable toxicity testing systems is an absolute necessity and can replace the enormous number of animal experiments that otherwise are needed to meet these requirements.

During the first three years of the project we performed numerous global transcriptional studies together with researchers at Collectis. The stability of commonly used reference genes was investigated in gene expression data during differentiation of human embryonic stem cells (hESC) from three cell lines. Notably, it was found that the transcription levels of many frequently used reference genes varied to a degree that rendered them inappropriate as reference genes in hESC. As a result, a novel set of genes that were expressed at a constant level in hESC was defined (Synnergren et al., 2007). Collaborating partners now routinely use several of these genes as references in their daily work both at Collectis and in other research groups. Researchers at the partner company performed the experimental part of this study, and Jane Synnergren performed the data analysis as the first part of her PhD project. This was followed by several extensive global transcriptional studies, mainly using microarray technology. Samples were collected during the differentiation processes towards the cardiac and hepatic lineages and novel biomarkers for different stages during the differentiation were defined

(Synnergren et al., 2008; 2008b, 2010). We and other investigators, both in academia and industry, now routinely use these novel markers for characterization purposes. To further examine the regulatory mechanisms controlling the differentiation processes, comprehensive clustering studies were also performed on the expression datasets to identify groups of genes with a mutual transcriptional profile (Synnergren et al., 2008). These clusters were then screened for common regulatory elements in their promoter regions and novel motifs were identified as potential regulators in some of these groups. At the end of her thesis work Synnergren expanded the transcriptional experiments to also include microRNA transcription (Synnergren et al., 2011), as these small molecules have been demonstrated to be important regulators in cell differentiation. Researchers at Cellectis performed the experimental part and Synnergren performed the data analysis and results from this analysis contributed to the last part in her thesis.

Since 2011, our stem cell research has rapidly expanded and we have received three large project grants in collaboration with industrial partners. By the end of 2012 four postdocs and a new PhD student were enrolled in the project and a second PhD student will be employed during 2013. The most recent studies have been focused on improvement of the functionality of the hESC-derivatives. Together with Cellectis and AstraZeneca advanced transfection studies have been performed to overexpress genes that are significantly under-expressed in hESC-derived cardiomyocytes compared to fetal and adult heart tissue (Synnergren et al., 2012b). Moreover, to better mimic the structural characteristics of an organ, we have together with Cellectis and researchers at the Karolinska Institute compared 2D and 3D culturing systems by differentiation of hepatocytes using a four compartment bioreactor diffusion system (Sivertsson et al., 2013).

Researchers in this project frequently participate in international conferences to present results from the project to the scientific community. During these five years Synnergren has participated and presented results in oral presentations, posters, or conference papers at 15 international conferences (Synnergren et al., 2007b; 2008c; 2010; 2012; 2012b; 2010c; 2012c; 2012d) and developed an extensive network with recognized international researchers and established several international collaborations.

The large datasets generated within this research project have been analyzed using advanced bioinformatic algorithms to reveal differences and similarities between the hESC-derived hepatocytes and cardiomyocytes and their *in vivo* counterparts. To fully utilize all the information that has been generated, the global datasets have been uploaded in public repositories and can now also be used by other investigators. In addition, the datasets and results are also

stored in a private database at the partner company Collectis and this work was implemented by researchers from the university. The database constitutes a valuable resource for Collectis and is also accessible by their customers through the company's webpage. Through this extensive work the company and their customers have easy access to all transcriptional data and this resource is used on a daily basis at the company.

Two US patents were granted based on results from this project. The first one covers results from characterization studies on hESC-differentiation towards the cardiac lineage and specifies characteristics of clusters of hESC-derived cardiomyocytes (Synnergren et al., 2008b). The second patent covers microRNA expression in hESC-derived cardiomyocytes where we were the first group to perform extensive miRNA profiling of a specific cluster format of cardiomyocytes (Synnergren et al, 2011). Both patents are being exploited by Collectis.

This research has been greatly supported by the two industrial partners Collectis and AstraZeneca. These companies have largely contributed to the success of this research by giving us access to their specially equipped research facilities and advanced instrumentation. Moreover, Collectis has free of charge contributed all stem cell products needed for the experiments performed during this 5-year period. AstraZeneca has continuously evaluated the improvements made in the project and benchmarked it to currently used methods in the industry.

The project has resulted in 13 articles in peer-reviewed scientific journals, for example *Stem Cells* (2 articles, current journal Impact Factor 7.781), *Physiological Genomics* (3 articles, 2.735), *Stem Cells and Development* (2 articles, 4.459), *Journal of Biotechnology* (1 article, 3.045), *Tissue Engineering* (1 article, 4.022), and *Toxicological Science* (1 article, 4.652). Including also full-length conference papers and book chapters, the project has resulted in more than 20 publications in total.

Provide references to:

- key research outputs evidencing the impact (list of publications, patents etc.),
- other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA

Peer reviewed scientific journal papers

Asp J, Synnergren J, Jonsson M, Dellgren G, Jepsson A (2012) Comparison of human cardiac gene expression profiles in paired samples of right atrium and left ventricle collected in vivo. *Physiol. Genomics* 44(1):89-98.

de Peppo GM, Svensson S, Lennerås M, Synnergren J, Stenberg J, Strehl R, Hyllner J, Thomsen P, Karlsson C (2010b) Human Embryonic Mesodermal Progenitors Highly

Resemble Human Mesenchymal Stem Cells and Display High Potential for Tissue Engineering Applications. *Tissue Eng. Part A* 16(7): 2161-2182.

Magnusson LU, Lundqvist A, Asp J, Synnergren J, Johansson CT, Palmqvist L, Jeppsson A, Hultén LM (2012) High expression of arachidonate 15-lipoxygenase and proinflammatory markers in human ischemic heart tissue. *Biochem Biophys Res Commun.* 424(2):327-30.

Sartipy P, Hyllner J, Olsson B, Synnergren J (2009) Regulation of 'Stemness' and Stem Cell Differentiation by MicroRNAs. *IDrugs* 12(8): 492-496.

Sivertsson L, Synnergren J, Jensen J, Björquist P, Ingelman-Sundberg M. (2013) Hepatic differentiation and maturation of human embryonic stem cells cultured in a perfused three-dimensional bioreactor. *Stem Cells Dev.* 22(4): 581-94.

Synnergren J, Giesler TL, Adak S, Tandon R, Noaksson K, Lindahl A, Nilsson P, Nelson D, Olsson B, Englund MCO, Abbot S, Sartipy P (2007) Differentiating human embryonic stem cells express a unique housekeeping gene signature. *Stem Cells* 25(2): 473-480.

Synnergren J, Adak S, Englund MC, Giesler TL, Noaksson K, Lindahl A, Nilsson P, Nelson D, Abbot S, Olsson B, Sartipy P (2008) Cardiomyogenic gene expression profiling of differentiating human embryonic stem cells. *J Biotechnol.* 134: 162-170.

Synnergren J, Åkesson K, Dahlenborg K, Vidarsson H, Améen C, Steel D, Lindahl A, Olsson B, Sartipy P (2008b) Molecular signature of cardiomyocyte clusters derived from human embryonic stem cells. *Stem Cells* 26(7): 1831-1840.

Synnergren J, Olsson B, Gamalielsson (2009) Classification of Information Fusion Methods in System Biology. *In Silico Biology* 9: 1-12.

Synnergren J, Heins N, Brolén G, Lindahl A, Hyllner J, Olsson B, Sartipy P, Björquist P (2010) Transcriptional profiling of human embryonic stem cells differentiating to definitive and primitive endoderm and further towards the hepatic lineage. *Stem Cells Dev.* 19(7): 961-978.

Synnergren J, Améen C, Lindahl A, Olsson B, Sartipy P (2011) Expression of microRNAs and their target mRNAs in human stem cell derived cardiomyocyte clusters and in heart tissue. *Physiol Genomics* 43(10):581-94.

Synnergren J, Améen C, Jansson A, Sartipy, P (2012b) Global transcriptional profiling reveals similarities and differences between human stem cell-derived cardiomyocyte clusters and heart tissue. *Physiol. Genomics* 44(4):245-58.

Yildirimman R, Brolén G, Vilardell M, Eriksson G, Synnergren J, Gmuender H, Kamburov A, Ingelman-Sundberg M, Castell J, Lahoz A, Kleinjans J, van Delft J, Björquist P, Herwig R (2011) Human embryonic stem cell derived hepatocyte-like cells as a tool for in vitro hazard assessment of chemical carcinogenicity. *Toxicological Science* 124(2):278-90.

Peer reviewed conference papers

Synnergren J, Olsson B, Gamalielsson (2007b), Mapping of the JDL Data Fusion Model to Bioinformatics, In *Proc. the 2007 IEEE International Conference on Systems, Man and Cybernetics (SMC 2007)*, page 1506-1511, 7-10 Oct, Montreal, Canada. ISBN: 978-1-4244-0991-4.

Synnergren J, Olsson B, Gamalielsson (2008c) A Data Integration Method for Exploring Gene Regulatory Mechanisms. *Conference on Intergration and Knowledge Management (CIKM)*, 26-30 Oct 2008, Napa Valley, California, USA.

Synnergren J, Özdoğan A, Olsson B, Sartipy P. (2010c) Clustering micro-RNA array data using an information fusion based approach with multiple types of input data. *Second International Conference on Bioinformatics and Computational Biology (BiCoB)*, 24-26 March 2010, Honolulu, Hawaii, USA.

Synnergren J and Sartipy P (2012c) Transcriptional analysis of messenger-RNA and micro-RNA array data reveals global negative correlation in human stem cell derived cardiomyocyte clusters. *The 4th International Conference on Bioinformatics and Computational Biology (BiCoB)*, 12-14 March 2012, Las Vegas, Nevada, USA.

Synnergren J (2012d) MicroRNA regulatory network involved in impaired functionality in cardiomyocytes derived from human embryonic stem cells. *The 25th international conference on computer applications in industry and engineering (CAINE)*, 14-16 Nov. 2012, New Orleans, Louisiana, USA.

Book chapters

Synnergren J and Sartipy P (2011) Microarray Analysis of Undifferentiated and Differentiated Human Pluripotent Stem Cells. In: *Methodological Advances in the Culture, Manipulation and Utilization of Embryonic Stem Cells for Basic and Practical Applications*. ISBN 978-953-307-197-8, Edited by: Craig Atwood, InTech..

Patents

Sartipy P, Åkesson K, Améen C, Dahlenborg K, Synnergren J, Steel D "Cardiomyocyte-like cell clusters derived from hES cells". WO2009036982, 26 March 2009.

Sartipy P, Synnergren J. "Novel microRNAs for the detection and isolation of human embryonic stem cell- derived cardiac cell types." WO2011EP59785, 14 June 2011.

PhD thesis

Synnergren, J. (2010). Transcriptional profiling of human embryonic stem cells and their functional derivatives. Göteborg University, ISBN 978-91-628-8169-6.

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Other aspects to highlight

We are now trying to broaden our stem cell project further by looking into novel approaches to increase the functionality of hESC-derived products. E.g. in July 2013 a new project with KF funding will be started where DNA methylation will be studied in detail. The aim of this project is to understand if methylated genes in in vitro cultures can explain some of the hampered functionality seen in ESC-derived hepatocytes.

We are also trying to broaden our project to include neural cells, which attracted AstraZeneca, 3Dtro and SciCross and a new project application to the KF Environment is under development and is being submitted on 14th June 2013.

Table C1.1.2 Template for impact cases (maximum 4 pages)

Title of case 2: **Stochastic operative models used for fisheries quota reference points in the Baltic Sea**

Research consortium and funding

This project was part of a larger consortium project *IBAM: Integrated Bayesian risk analysis of ecosystem management in the Gulf of Finland*. The IBAM project was divided into work packages, which were led by principal scientists: Professor Ari Jolma, Aalto University School of Engineering, Finland, Dr. Robert Aps, University of Tartu, Estonia, Professor Noël Holmgren (NH), University of Skövde, Sweden, and Dr. Heikki Pitkänen, Finnish Environment Institute, Finland. The IBAM project was coordinated by Professor Sakari Kuikka, University of Helsinki, Finland. The impact case described here is from WP2: *Herring fisheries analysis by Bayesian quotas and by stakeholder specific risk models*. Participants in the work package were: Niclas Norrström, University of Skövde, Sakari Kuikka, Robert Aps, and Mihhail Fetisov, University of Tartu. The project received funding by the European Commission's Seventh Framework Programme under grant agreement 217246 made with the joint Baltic Sea research and development programme BONUS, from FORMAS, Sweden, the Academy of Finland, and an Estonian Science Foundation grant 7609, Estonian target financed theme SF0180104s08, in total € 889 000.

The impact domain

It was from the beginning of the project, an objective to interact with the International Council for the Exploration of the Seas (ICES; www.ices.dk). ICES is an organization of 20 member countries, EU-countries with fishing rights in the North Atlantic and the Baltic Sea, but also non-EU countries like Canada, Iceland, Norway, Russia and the USA. On request from its member countries ICES provides scientific advice for fisheries quota of the commercial fisheries

in the North Atlantic and the Baltic Sea. ICES also organize researchers to advance research on enhanced sustainability of the oceans, including the impact of resource utilization. In total, ICES engages more than 4000 scientists from almost 300 institutes.

At the start of the project, NH was appointed as a Swedish delegate of the Baltic Fisheries Assessment Working Group (WGBFAS). The appointment was a clear success factor for the impact we have had with our research. It is only appointed delegates that have the right to participate in the whole meeting and gets access to ICES resources. The appointment is until further notice, and hence NH is still a member. The annual procedure is to assemble data from commercial landings, surveys and samples of the stocks regarding life history parameters and age structure. The data is input to maximum likelihood stock assessments. The quotas are then calculated based on calculated targets for the stocks. This is where our work comes in. We provide targets that give maximum sustainable yields (MSY) using stochastic operative models of the stocks (SOM). The WGBFAS reports are co-authored by the meeting (the authors are listed in the beginning of the report, but always referred to as ICES report), with the labour assigned to specialists of different issues. We have been writing the sections on reference points, and multi-species considerations in the reports of the WGBFAS. All results have to be acknowledged by the meeting, and the text is reviewed by internally assigned reviewers who give a written statement.

Description of impact

During the period of 2010 to 2015 the ICES, on request from the European Commission (EC), is gradually changing their advice from a precautionary approach to an advice based on maximized sustainable yields. There is also a demand from the commission to adopt an ecosystem-approach in the advice. This requires a timely change in the work process of ICES assessment groups in order to fulfill the aim of the EC having the stocks in the state of delivering MSYs by 2015. Reference points (e.g. targets and safety limits) must be developed in relation to the drivers of stock productivity, usually in the terms of a FMSY analysis in which exploitation is varied and other drivers are kept constant (ICES, 2011b). Thus, biological reference points are specific to drivers' state, which must be estimated directly or indirectly e.g. as effects on growth or natural mortality. ICES gives priority to stochastic models over yield-per-recruit (YPR) analyses (Beverton and Holt, 1957) as a basis for MSY reference points (ICES, 2011b). We were therefore asked in 2011 by the WGBFAS chair to support the stock coordinators and provide reference points from our stochastic operative model developed in the IBAM project. With estimated dynamics for both population numbers and body weight for age structured

populations, it is regarded as the most appropriate model for the Baltic Sea pelagic stocks by ICES. We provided a complete set of the new MSY reference points for herring in the central Baltic Sea (subdivisions 25-27, 28.2, 29 and 32), herring in the Bothnian Sea (subdivision 30), and sprat in the central Baltic Sea (subdivisions 22-32). This includes the target fishing mortality (FMSY), the range of fishing mortalities in which yields are no less than 95 % of MSY (FMSY-max and FMSY-min), the threshold spawning stock biomass below which fishing mortality must be reduced and the basis for the advice be revised (B-trigger), and estimates of MSY and SSB at FMSY which can be found in the final report. In the final report of WGBFAS the FMSY of herring and sprat in the central Baltic Sea were adopted (ICES, 2011a). The result from another methodology was used for herring in the Bothnian Sea. The meeting decided not to include any other MSY-related reference points as of this year. The SOM was adopted for herring in the Bothnian Sea in 2013 (ICES, 2013b). Our current work on the reference points is to link the stocks of the Baltic Sea in a multi-species interaction stochastic operative model, MSI-SOM. This model will hopefully be the basis of the new reference points being ecosystem based and taking into account ecological interactions. The MSI-SOM results will be published in the WKBALT report (ICES, 2013a). Besides the research with direct impact on the fisheries management, the WP produced two additional publications (Aps *et al.*, 2011; Aps *et al.*, 2012).

The scientific result and link to impact

The Baltic Sea ecosystem has undergone dramatic changes, so-called ecosystem regime shifts, during the past four decades. Baltic Sea herring (*Clupea harengus*) spawning-stock biomass has declined to a third, and weight-at-age has halved as a result of food shortages and competition with sprat (*Sprattus sprattus*) since the early 1980's. The management objective for the herring stock is currently in transition from precautionary to maximum sustainable yield (MSY). This warrants new biological analyses of drivers of productivity and compensatory dynamics in order to account for the numerical and weight changes that have been observed. Stochastic temporal variability and uncertainty of stock size adds to the challenges of fisheries management. If not managed appropriately, this can lead to suboptimal harvests, inflated temporal variability, increased risk of stock extinction and unwanted cascade effects in the ecosystem. The project aim was to study the ecological drivers for stock production and how it affected MSY. In addition we evaluated alternative harvest controls, especially a combined catch and effort stock regulation which takes into account the uncertainty in the assessments.

The main basin Baltic Sea herring was modelled under the current ecosystem

regime and the effect of a recovery of the cod (*Gadus morhua*) stock and availability of planktonic food to levels found in the early 1980s analysed. A target of $F_{MSY} = 0.16$ for herring, which should decline to $F_{MSY} = 0.10$ with recovery of the cod stock is proposed. An increase in availability of planktonic food is estimated to more than double the yield at $F_{MSY} = 0.27$, overriding the negative effects of cod predation should there be a simultaneous increase in both cod and availability of planktonic food. If both cod predation and food abundance increase food abundance is the dominating factor and the estimated net increase in yield is 40% at $F_{MSY} = 0.20$. Functions were presented to calculate F_{MSY} and to estimate the expected yield depending on the abundance of cod and food availability. Retrospective application of the functions indicates overfishing of herring in the 1990s and early 2000s, resulting in an estimated net loss in yield, with a landing value of some €440 million (Fig. 1;) (Holmgren *et al.*, 2012).

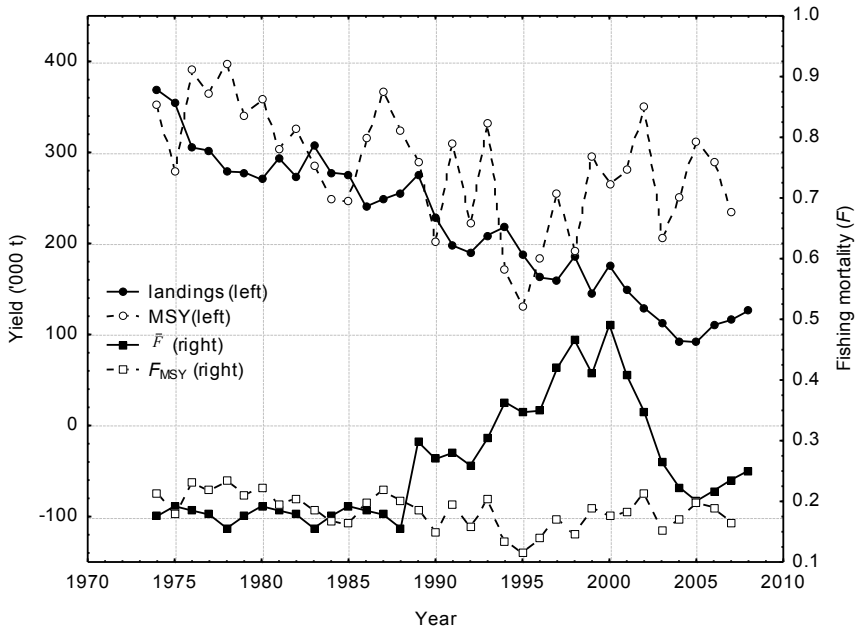


Figure 1. Yield (circles) and fishing mortality (squares) according to historical records (ICES; filled symbols) and if F_{MSY} had been applied with reference to cod SSB and food availability (open symbols). The actual fishing mortality was considerably higher than F_{MSY} during 1989–2004 (compare solid with open squares). This led to suboptimal landings from 1999 and onwards (compare solid with open circles).

The original objective of the IBAM WP and developing the SOM, was to evaluate new methods of harvest control (Holmgren *et al.*, 2013). For this, we have adapted Bayesian foraging theory to fisheries and developed a combined

catch and effort harvest control – Bayesian quota (BQ). The BQ provides real-time Bayesian estimates of stock size. As such it can operate without annual assessment, i.e. unsupervised. We compared the performance of BQ with supervised total allowable catch (TAC) regulation that is used today by virtual fishing on an operative model of the herring in the main basin of the Baltic Sea. We investigated the effect of having fishing mortality, F , and population size, N , as operational targets. BQs operated with N -target gave on average 3 % higher yields than BQ and TAC operated with F -target. Using operational N -targets led to considerably higher temporal variation in yields and fishing effort compared to F -targeted management. On the contrary, N -targeted BQ led to less temporal variation in SSB and population size, whereas it increased with N -targeted TAC. All harvest controls reduced the amplitude of temporal variation in population size compared to the unexploited population. F -targeted BQs and both TACs increased the dominating periodic length of the temporal variation in population size from 20 years of the unexploited stock to 60-80 years. Such long term fluctuations are observed in the Baltic Sea pelagic stocks, and are naturally hard for managers and fishing industry to cope with. N -targeted Bayesian quotas reduced the dominating periodic variation to become more similar to white noise with a dominating periodic length of 12-16 years. The pros of low temporal variability in yield and effort of F -targeted fisheries should be compared with the benefits from somewhat higher yields and reduced amplitude and period length in population size and SSB of N -targeted BQ. Our study shows that unsupervised BQ performs as well as supervised BQ, but has a clear advantage of not requiring the demanding annual assessments of current management. This makes BQ suitable for stocks with no or poor assessments. The ecosystem implications of fisheries induced temporal variability of long period lengths is worth more scientific attention. Even though our current research is focused on the ecosystem approach, fisheries induced dynamics and methods for harvest control are highly relevant when giving advice on fisheries quota.

Provide references to:

- key research outputs evidencing the impact (list of publications, patents etc.),
- other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA

Aps R., Fetissov M., Holmgren N., Norrström N., and Kuikka S. 2011. Central Baltic Sea herring: effect of environmental trends and fishery management. In *Ecosystems and Sustainable Development VIII*, pp, 69-80. Ed. by Y. Villacampa, and C. A. Brebbia. WIT Press Southampton, Boston.

Aps R., Fetissov M., Holmgren N., Norrström N., and Kuikka S. 2012. Fisheries management: from linear to collaborative science-policy interface. In *Management*

of Natural Resources, Sustainable Development and Ecological Hazards, pp, 3-14. Ed. by C. A. Brebbia, and S. S. Zubir. WIT Press, Southampton.

Beverton R. J. H., and Holt S. J. 1957. On the Dynamics of Exploited Fish Populations. HM Stationery Office, London.

Holmgren N. M. A., Norrström N., Aps R., and Kuikka S. 2012. MSY-orientated management of Baltic Sea herring (*Clupea harengus*) during different ecosystem regimes. ICES Journal of Marine Science, 69: 257-266.

Holmgren NMA, Norrström N, Aps R, Kuikka S. 2013. Using animal behavior theory in fisheries - the application of Bayesian quota to Baltic Sea herring management. (submitted to Canadian Journal for Fisheries and Aquatic Sciences, under revision)

ICES. 2011a. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 12 - 19 April, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:10. 785 pp.

ICES. 2011b. Report of the Workshop on Implementing the ICES Fmsy Framework (WKFRAME-2), 10-14 February 2011, ICES, Denmark. ICES CM 2011/ACOM:33. 110 pp.

ICES. 2013a. Report of the Benchmark Workshop on Baltic Multispecies Assessments (WKBALT), 4-8 February 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:43. 201 pp.

ICES. 2013b. Report of the Inter-Benchmark Protocol for Herring in Subdivision 30 (IBP Her30), 11-15 March 2013, By correspondence. ICES CM 2013/ACOM:60. 94 pp.

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UNIVERSITY
OF SKÖVDE

Self-assessment

The Virtual Systems Research Centre

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ARC13 – Evaluation Package

Introduction

The following document describes the research and collaboration of defined units of assessment (UoA) at the University. The document includes indicators on research activities, research initiatives and collaboration in research in relation to academic, business, or public partners. The document also includes a qualitative self-assessment of the strengths, weaknesses, opportunities and threats (SWOT) of the UoA. The indicators aim to describe research activities in specific areas as well as in multi-disciplinary fields. Apart from direct research quality assessments, a number of different aspects are requested to be elucidated; description of the research field, research environment and infrastructure, research output, impact, engagement and co-operation with society (which in this document denotes organisations within business and public sector, non-governmental organisations, the public, but not including other academic institutions) and opportunities for renewal and actions for successful development. The document also includes two case descriptions identified by the UoA as particularly important or significant (see C). The document is structured in three parts:

Part A – Strategic information about the UoA (general description and SWOT-analysis)

Part B – Quantitative data describing the UoA (general information, research output and co-operation with society)

Part C – Case descriptions (two impact cases)

The parts are complementary. Information provided in either part should be used to support and deepen the information presented in the other.

ARC13 generally assesses the period January 2007 to the end of December 2012 (see appendix 1), although some of the indicators cover a shorter period of time. The expert panels are asked to assess the quality of research (and collaboration) at the UoA in an international perspective based on the instructions given in the *Terms of reference* (Appendix 1). In particular, the panels are asked to identify **strong research activities, strong collaboration with society** and **potentially interesting opportunities for development**.

Part A: Strategic information from the unit of assessment (UoA)

In this part of the evaluation package the UoA communicates information on organisation, co-operation and strategies chosen to ensure that relevant, high-quality research is conducted.

Table 0 – Name of the UoA	
Name of Unit of assessment	VIRTUAL SYSTEMS RESEARCH CENTRE
Coordinator of Unit of assessment	Josef Adolfsson

A1. Description of the research in the UoA

This is an overview of the current research areas, including primary missions and goals, within the UoA. (Max 4 pages, in template format):

The UoA, i.e. Virtual Systems Research Centre (VSRC), was established in 2007 and the objective by that time was to form an interdisciplinary research centre dealing with applications of virtual systems and related technologies in a broad sense, using modelling and simulation in areas such as: engineering, design, learning, entertainment and decision support. The original composition was therefore formed with research groups from the following disciplines: Automation engineering, Mechanical engineering, Integrated product development, Social psychology, Serious games and Logistics.

University of Skövde is located in a region that is one of the densest industrial regions in Sweden with a large number manufacturing companies, which makes collaboration with society an important objective. Applied research is the main category of research carried out by VSRC, and the research is heavily driven by demands from society. Through the years since the establishment of VSRC, the research has evolved towards being more focused on industrial demands, and the composition of VSRC has changed accordingly. Consequently, today VSRC consists of the following disciplines:

- Automation engineering
- Mechanical engineering
- Integrated product development

The main objective of VSRC is to use and develop computer-based tools and models with focus on the development of products, processes and systems. The use of these tools and models enables testing product, process or system characteristics in virtual environments, representing real-world characteristics, without actually working in the physical world directly. The virtual approach is beneficial since working in the physical world is often costly and slow or even impossible, e.g. due to the need to create physical prototypes or disturbing real-world systems. Hence, product and production development have seen an increased use of computer-based virtual tools, which is a common ground for the research within VSRC. Simulation tools are for example used to study materials' strength and fatigue properties, to study ergonomics (human-product interaction) with respect to user diversity, and to study the performance of single machines up to whole systems. Today, the centre covers the research and application areas shown in Figure 1. The successful work of VSRC within the area of computer-based tools is the key factor that rendered VSRC to be elected by AB Volvo as the Volvo Global Preferred Academic Research Partner within the area of Virtual Manufacturing from 2009.

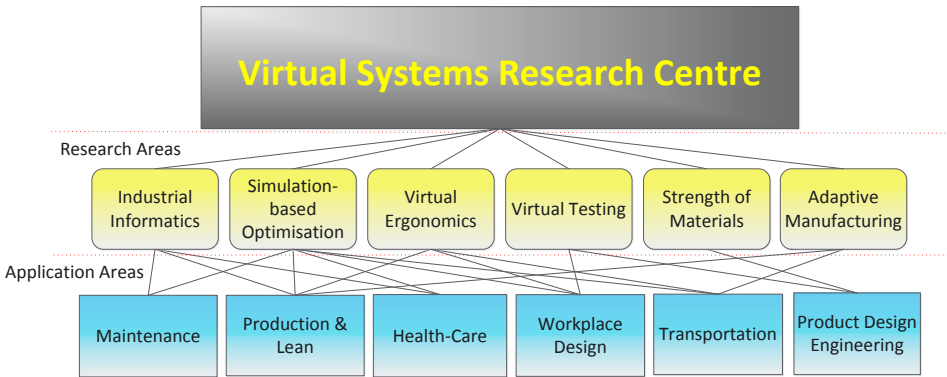


Figure 1. Research and application areas of Virtual Systems Research Centre

The different research areas are: *industrial informatics*, *simulation-based optimisation*, *virtual ergonomics*, *virtual testing*, *strength of materials* and *adaptive manufacturing*. These research areas are applied for different application areas as shown in Figure 1 and are performed by the three research groups within VSRC: *Mechanics of Materials (MoM)*, *User Centred Product Design (UCPD)* and *Intelligent Automation (IA)*. These groups jointly form a strong foundation for the research carried out in the research centre. The synergistic effects within the research centre are achieved by carrying out joint

research projects. These projects can be of theoretical nature and deal with mutually shared research questions such as: (i) theoretical frameworks and standards for virtual systems, (ii) methods, tools and algorithms for virtual systems, (iii) infrastructures (hard- and software) for virtual systems, and (iv) the role of people and organisations for virtual systems as well as the implications of the use of virtual systems for people and organisations. Such projects also benefit from results generated in other research projects that address similar problems in different sectors; an example is the use of production simulation tools to carry out studies for healthcare providers. The beneficiaries from the research include the private and public sectors, as well as individuals. The research centre has a wide local, national and international network which makes it easy to identify and involve additional research competences and resources when needed.

Another way to describe the research within VSRC is to illustrate how the three research groups are dealing with different aspects of the development of products, processes and systems, as shown in Figure 2.

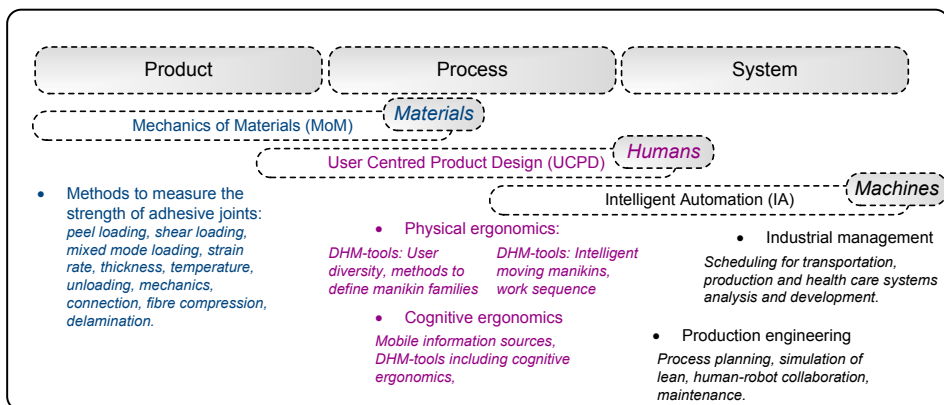


Figure 2. Research of the groups within VSRC

The following sections include more detailed descriptions of the three research groups and their areas of research.

Mechanics of Materials (MoM)

Methods to analyse the strength of engineering materials and structures are studied in the group “Mechanics of Materials” (MoM). The theoretical basis for these studies is cohesive modelling together with more traditional and well-established theories, e.g. the theories of elasticity, plasticity and continuum

damage mechanics. Within the field of cohesive modelling, MoM develops novel methods to measure cohesive laws for adhesive joints. More recently, MoM is developing methods for measuring cohesive laws associated with delamination and compressive failure of composites. These methods are based on the principle of equilibrium of configurational forces. In an on-going project, MoM study fatigue properties of adhesive joints. The ambition is to be able to use similar simulation tools to analyse the fatigue properties of structures, as is used to analyse the strength. Jointly with these efforts to develop method for measuring the relevant properties, MoM is developing simulation tools. These efforts lead to new user elements and user material models to be used with finite element programmes.

The ambition is to develop methods based on sound physical and engineering principles that are useful for industrial applications. MoM aims at treating all aspects from measurements on test specimens, to simulations on a structural length scale.

User Centred Product Design (UCPD)

The activities within the UCPD (User Centred Product Design) research group aims to enhance knowledge about, and to develop tools and methods for, successful integration of user aspects in modern industrial product and production development processes. Hence, design and product development methodologies and philosophies which emphasize *the user* and *the use*, as important aspects to consider when developing products and workstations, are central fields for the research. In a wide perspective, UCPD's mission encompasses design issues related to all kinds of interaction between users and the designed world. Still, up to now the research has mainly dealt with utilitarian types of interaction, aiming to lead to designs with high quality in terms of level of accommodation, comfort, ergonomics, efficiency, usability, inclusion and similar values. Hence, research within physical and cognitive ergonomics (*human factors*) is closely related to UCPD's main research activities. Through the years, some research activities has also been directed towards more subjective values such as users' experiences or emotions when interacting with the designed world, but this far the research activities within that field has been rather reduced.

Since product and production development more commonly are performed in *virtual worlds*, using computers to aid the design and engineering process, UCPD have the additional mission to incorporate research results in computer based tools, such as digital human modelling (DHM) tools. In essence, the research activities within UCPD can be seen as separated into two related

themes: *physical ergonomics* and *cognitive ergonomics*. This far, mainly the research results within the physical ergonomics theme has been incorporated into computer systems, in terms of the joint development of the Swedish DHM tool IMMA (Intelligently moving manikins). A future objective is to also incorporate design support functionality for cognitive ergonomics in DHM tools. Hence, a long term objective is not to make the two sections of UCPD separate when research activities expand, but rather the opposite; it is seen as a strategic advantage to keep the combined picture, where the research about successful integration of user aspects in design processes consider humans as both physical and thinking beings.

In short, a central aim of the research is to assist in making ergonomics information relevant and easily available to designers and engineers, and to support the consideration of user centred aspects along with other requirements in the complex time and budget constrained industrial product development reality.

Intelligent Automation (IA)

The research of the Intelligent Automation (IA) group within VSRC covers several strategically important areas within production engineering and industrial management that are highly relevant and may offer potentially significant benefits to both the nation and local societies. These research areas include simulation-based optimization, adaptive manufacturing, transportation informatics and optimization, health-care simulation and optimization as well as Lean manufacturing.

The University of Skövde has clearly defined Information Technology (IT) as their key research profile, and IT is the subject in which the PhD examination authority was granted from 2010. Among the three research directions under IT (i.e. *Computer science*, *Socio-technical systems* and *Industrial informatics*), Industrial informatics (IIF) is the one that has strongest connections to industrial applications. IIF tools are used primarily for analysis, information management, decision-making support and distributed collaboration. Virtual systems and simulations are the main tools used within IIF for the design, analysis and optimization of products and workplaces. In terms of decision-making support, using a combination of artificial intelligence and simulation tools to generate and analyse a large amount of potential solutions and then present the optimal ones to the decision maker, is so-called simulation-based optimization (SBO). The IA group has built up extensive competences in the area of SBO since 2005. These competences are highly sought by industries, particularly automotive manufacturers, including long-term collaborating

partners like AB Volvo, Volvo Car Corporation (VCC) and Scania CV. The ultimate goal of SBO research is to develop advanced methodologies and toolsets that will create real impact to decision-making activities related to manufacturing, transportation and health-care systems as well as to leverage their efficiencies and sustainability.

Apart from applying SBO to manufacturing industries, the adaptive manufacturing research within the IA group is focused on adaptive process planning, web-based real-time monitoring, remote control, human-robot collaboration, operator assistance and condition-based predictive maintenance. The ultimate goal of the on-going research is to achieve real-time adaptability of manufacturing operations in dynamic environments, using intelligent function blocks with embedded algorithms. The outcomes are programming free for end users, safe for operators, adaptive to changes and cost effective.

A2. Summary of the scientific results

This qualitative summary of the most important scientific results of the UoA should reflect the width of the research and make reference to no more than 30 publications (Table A2.1) and other research outputs (Table A2.2). The summary should include comments to the publication and citation profile as presented in section B2.2, including the coverage of output from staff no longer affiliated to the UoA.

The main emphasis within the Virtual Systems Research Centre (VSRC) is on performing applied research, mainly driven by the needs from industry. Therefore, projects are performed in co-operation with industrial partners. There are several benefits of such close cooperation, e.g. that research results are not only published in journals or presented at conferences, but also that research results often are shown in demonstrators to visualize the concepts or directly implemented by the industry. A number of examples of how the results have affected the society are described in the following sections. Besides that, a general observation regarding publications is that the number of scientific publications created by researchers within VSRC has increased in the last few years, especially for peer reviewed articles in journals (Table B2.2.1 and B2.2.2). One explanation is that the number of granted research projects and people involved in research has increased during the same time period. At the same time, the research groups in VSRC have established cooperation with international researchers in the field of research, which has led to more publications in high ranked journals. The number of published book chapters has also increased, as well as the number of book editorships, during the last

few years. When it comes to citations there is a peak in 2006 due to one specific article (Andersson and Stigh, 2004) which presented a method to measure properties for adhesive layers. To date, this paper has been cited 121 times. The paper was also awarded as the most cited article in International Journal of Solids and Structures 2004 to 2008. With the method presented in this paper, it was possible to measure data that, up to this time, only had been possible to deduce through inverse techniques. It is still one of only a handful of methods to measure these properties. The second paper to receive a large interest is Leffler et al. (2007). In this paper, a similar technique is presented for measuring properties in another loading mode. It is now cited 85 times according to Google Scholar.

The following sections include a more detailed description of the different research groups and areas.

Mechanics of Materials (MoM)

In a number of projects, starting in the 90's, methods have been developed to model, characterize and measure properties determining the strength of adhesive joints. The theory behind a method to measure the properties of a model of the mechanics of an adhesive layer was developed in Olsson and Stigh in 1989. Development of the experimental method for peel loading was reported in a number of papers, cf. e.g. Andersson and Stigh (2004). A complementing method to measure the properties in shear loading was developed in a series of papers, cf. e.g. Leffler et al. (2007). Some requirements on the specimens could be relaxed using an alternative method presented by Stigh et al. (2009). A method to measure the properties in mixed mode loading was developed in Högberg et al. (2007).

Influences of strain rate, layer thickness and temperature were studied by Carlberger et al. (2009), Carlberger and Stigh (2010). The influence of temperature has also been studied in a licentiate thesis by Walander in 2013. Unloading characteristics were studied in Biel and Stigh (2010).

In order to increase the understanding of the mechanics of adhesive joints, a number of micromechanical studies were conducted, cf. e.g. Salomonsson and Andersson (2007).

Finite element formulations of the method were developed by Stigh in 1989. Later, formulations were developed suitable for the connection of an adhesive layer to the surface of a shell structure, cf. Carlberger et al. (2008) and Salomonsson and Stigh (2008).

Similar methods and studies have more recently been used to understand and model fracture of carbon fibre composites. In Svensson (2013), studies of fibre compressive failure and delamination were presented.

User Centred Product Design (UCPD)

Since the beginning of the development of DHM tools in the 70s, an objective has been that the tools shall support design of items such as vehicle interiors or workplaces. The elementary idea to reach that objective is by offering a changeable computer model of the human that facilitates the study of humans' interaction with the surrounding environment. Hence, the DHM tool gives valuable feedback to the design process, especially when the design work is performed using computer aided design (CAD) tools. However, often DHM tools available on the market needs to be adapted to companies' work processes, routines and standards in order to fit into, and gain, the regular development process. This area has been a central matter within UCPD and the research, performed with tight industrial collaboration, is described in Högberg et al. (2008). The paper describes three industrial cases of how major Swedish vehicle manufacturers have adapted DHM tools to fit into their product and production development processes. This includes the incorporation of companies' own established ergonomics evaluation methods in the DHM tools, as well as the development of a DHM usage process suited to the general product development process at a company. This research is further developed in Högberg et al. (2008), where DHM tools were adapted to suit a company that develops health care products. The paper describes how the design method *personas* (user characters) was implemented in DHM. Hence, the computer manikin was equipped with personal traits rather than just being an anonymous model. When designing products it is central to consider user diversity, and this is equally important when using DHM tools. Even though human diversity covers a wide range of matters, where some are hard or impossible to consider when using a DHM tool, handling of anthropometric diversity is an area where the DHM tool certainly can support the design process. This concern is discussed in Högberg (2009) where issues of inclusive design and accommodation are discussed and the use of systematic manikin families is illustrated, where each manikin (virtual test person) has different anthropometry. The methodology to define appropriate manikin families is further developed in Högberg et al. (2012) and Brolin et al. (2012).

In 2009 UCPD got involved in a research project called IMMA (Intelligently moving manikins) (Hanson et al., 2011) where UCPD, in collaboration with Fraunhofer Chalmers Centre (FCC), Chalmers and Swedish industry, develops an own DHM tool. One feature of the IMMA tool is that it has automatic path

planning functionality which facilitates simulation of full work sequences. With this follows the need to be able to evaluate full work sequences from a physical ergonomics point of view. The approach to assess ergonomics in IMMA is to get inspiration from how direct technical measurement within epidemiologic research is performed and to use that knowledge about risks for developing work-related musculoskeletal disorders (WMSDs). The status of this work is reported in Rhen et al. (2012).

One step towards the long term objective of the UCPD to be able to support designers with DHM tool functionality to consider users' physical and cognitive conditions and capabilities is the discussion of potential approaches presented in Thorvald et al. (2012a). The suggested approach is, at least initially, to keep a basic approach, which is based on supporting the DHM tool user with functionality, support and tips of how to consider cognitive ergonomics, rather than aiming to simulate the human mind.

Activities within UCPD that are directed to cognitive ergonomics are reported in Thorvald et al. (2010) and Thorvald et al. (2012b). The cognitive ergonomics team of UCPD have mainly been investigating assembly workstation design and its implications on human assembly behaviour. Thorvald et al. (2010) investigates the use of mobile information sources in manual assembly and the case study reported in the paper shows significant benefits from using mobile information sources as opposed to stationary ones under certain conditions. Thorvald et al. (2012b) reports a case study where actual assembly workers were tasked with creating Lego® assemblies under three different information presentation conditions. The paper confirms previous thoughts and hypotheses within the research group that the layout and sequencing of assembly information greatly affects assembly output. Said paper also fails to confirm the benefits of using symbols as opposed to article numbers to identify parts although this is later confirmed in a still unpublished case study.

Intelligent Automation (IA)

While data mining has been described as a technology which will launch a new revolution on how scientific research is conducted, there are only a few efforts that explicitly recognise the power of combining SBO and data mining. The uniqueness of Innovization (Innovation via Optimization), as has been shown in the FFI-HSO (Holistic Simulation Optimization) project led by the IA, is in using advanced data analysis techniques to decipher salient properties from the optimization data generated, and not data that already exist in a data source. As a matter of fact, by integrating the concept of innovization with simulation and data mining techniques, the innovization task can be used effectively for

the analysis and decision-making support in any product/system design that involves simulation. Such a so-called Simulation-based Innovization (SBI) procedure, was first proposed by IA in 2009. Later, a more complete decision-tree based SBI procedure and its industrial application studies, have been reported in several publications (Dudas, Frantzen and Ng, 2011; Ng, Dudas and Deb, 2011). In a recent paper, it has been shown that the rules generated from SBI can be used as the constraints in the original optimisation to enhance it to converge to the decision maker's preferred region. The paper received the best paper award within Industrial Automation at the Swedish Production Symposium 2012.

The development of FACTS Analyser (hereafter FACTS) and its well-acceptance by the Swedish automotive companies, particularly Volvo Car Corporation, is another good demonstration of the quality of the research of IA in the area of production systems simulation and optimization. FACTS is a software tool developed specifically for supporting factory design, analysis and optimization during the conceptual design phase. From a scientific perspective, with its rapid modelling capability and inherent SMO support, FACTS is a perfect tool for researchers to perform performance analysis and comparative studies on different manufacturing control and/or flow concepts/strategies. This is best exemplified by the application studies published in (Ng, Bernedixen and Syberfeldt, 2012).

In terms of research in optimisation algorithms, a new variant of evolutionary algorithms (EA) with dynamic resampling, specifically designed for handling noises or stochastic simulation outputs, called "Multi-Objective Parallel Surrogate-Assisted EA" (MOPSA-EA), was conceived (Syberfeldt et al., 2010). Very recently, IA is investigating the integration of various dynamic resampling strategies with an extended reference point based guided search algorithm, namely R-NSGA-II, which can take into account the preference information given by the decision maker to guide the optimization towards interesting, preferred regions. Unlike other related work in dynamic resampling strategies, the uniqueness of the current attempt is that the computing budget allocation is devised to be proportional to how close the solutions are to the preferred region, instead of the entire Pareto front or other statistical measures (Siegmond, Ng and Deb, 2012).

An integrated approach for remote real-time monitoring of manufacturing operations was presented in (Wang et al., 2011). It is enabled by using virtual 3D models driven by real sensor data. The objectives of this research are twofold: (1) to significantly reduce network traffic for real-time monitoring over the internet; and (2) to increase the controllability of manufacturing systems from anywhere in a decentralised environment. Particularly, this paper

covers the principle of the approach, system architecture, prototype implementation, and a case study of remote control of a robotic assembly cell. Compared with camera-based monitoring systems, this approach only consumes less than 1% of its network bandwidth, making it feasible and practical as a web-based portable solution.

A function block enabled approach towards adaptive process planning and machining was introduced in (Wang, Holm and Adamson, 2010). A two-layer structure of supervisory planning and operation planning is proposed to separate generic data from machine-specific ones. The supervisory planning is only performed once, in advance, at the shop level to generate machine-neutral process plans, whereas the operation planning is carried out at runtime at the machine level to determine machine-specific operations. Such dynamic decision making is facilitated by resource-driven algorithms embedded in the function blocks. It is expected that the new approach can greatly enhance the dynamism of fluctuating job-shop machining operations.

Wang et al. (2010) proposed a decision-making approach towards adaptive setup planning that considers both the availability and capability of machines on a shop floor. It loosely integrates scheduling functions at the setup planning stage, and utilises a two-step decision-making strategy for generating machine-neutral and machine-specific setup plans at each stage. The objective of the research is to enable adaptive setup planning for dynamic job shop machining. Particularly, this paper covers basic concepts and algorithms for one-time generic setup planning, and run-time final setup merging for dynamic machine assignments. The decision-making algorithms validation is further demonstrated through a case study.

Wang (2008) proposed an integrated approach for web-based collaborative manufacturing, including distributed process planning, dynamic scheduling, real-time monitoring and remote control. It allows users to plan and control distant operations based on runtime information. The objective of this research is to develop methodology and algorithms for web-based collaborative planning and control, supported by real-time monitoring for dynamic scheduling. Details on the principle of a Wise-ShopFloor framework, system architecture and a proof-of-concept prototype are reported in this paper. An example of distributed process planning for remote machining is chosen as a case study to demonstrate the effectiveness of this approach towards web-based collaborative manufacturing.

Table A2.1. Selected peer-reviewed publications¹**Mechanics of Materials (MoM)**

Andersson T, Stigh U (2004) The stress-elongation relation for an adhesive layer loaded in peel using equilibrium of energetic forces. *Int J Sol Str* 41:413-434. DOI:10.1016/j.ijsolstr.2003.09.039

Biel A, Stigh U (2010) Damage and plasticity in adhesive layer - an experimental study. *Int J Fract* 165:93–103. DOI: 10.1007/s10704-010-9508-3

Carlberger T, Alfredsson KS, Stigh U (2008) FE-formulation of Interphase Elements for Adhesive Joints. *Int J Comp Meth Engin Sci & Mech*, 9:288 - 299. DOI: 10.1080/15502280802229590

Carlberger T, Biel A, Stigh U (2009) Influence of temperature and strain rate on cohesive properties of a structural epoxy adhesive. *Int J Fract.* 155:155-166. DOI: 10.1007/s10704-009-9337-4

Carlberger T, Stigh U (2010) Influence of layer thickness on cohesive properties of an epoxy-based adhesive – an experimental study. *J Adh*, 86:814–833. DOI: 10.1080/00218464.2010.498718

Högberg JL, Sørensen BF, Stigh U (2007) Constitutive behaviour of mixed mode loaded adhesive layer. *Int J Sol Str*, 44:8335–8354. DOI: 10.1016/j.ijsolstr.2007.06.014

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¹ Publications should be listed in Harvard format. DOI=The Digital Object identifier system, for scientific publications is added in the following format: DOI: 10.1016/j. tibtech.2007.05.002 As a service for the expert panel, the listed publications are available to the expert panel as pdfs. Where the publication takes the form of a book, two copies should be provided.

Table A2.2. Other major research outputs¹

Type of output	Main person responsible	Description	Date when became publicly available
Method	Ulf Stigh	Methods to measure cohesive properties	2008-2012
Method	Erik Brolin	Boundary case method with mathematical description	2012
Research findings	Peter Thorvald	Evaluation of concept for manual assembly information using mobile device	2010

Software	Dan Högberg (for UCPD developed functionality)	IMMA DHM tool	Available to the project's industrial partners from 2010. Available to the public approx. 2015.
Software	Amos Ng	FACTS Analyser (Simulation and optimization for conceptual factory design and analysis)	Available to the research partners since 2008. Planning to be a commercial solution within 2013.
Software	Anna Syberfeldt	iCan - A comprehensive software and hardware system for management, planning, optimization, operation, and monitoring of transports and transport missions.	Available to the research partners since 2012. Planning to be a commercial product.
Software	Lihui Wang	Wise-Shopfloor	Available to the research partners like VCC since 2011.

¹ There is a maximum number of research output submissions allowed. The number of key research outputs, whether publication or other research output, is limited to the total number of professors within a UoA multiplied by four. The number should be four in case the UoA does not have a professor. Internationally acknowledged research outputs such as new materials, products and processes, patents, software, computer code, standards documents, evidence synthesis including systematic reviews, analyses, meta-analyses, research-based clinical case studies that add new knowledge, physical artefacts such as images, materials products and processes, prototypes, digital artefacts such as datasets, software, film and other non-print media etc.

A3. Research environment and infrastructure

In this section, the UoA presents the research environment that constitutes the context and breeding ground of its research.

A3.1 Organisation of the UoA

A description of how the UoA is organised; how research is managed and quality-secured; a presentation of research groups; how efforts of fund-raising are structured. (Max 2 pages for UoA and an additional ½ page per group)

Virtual Systems Research Centre (VSRC) is formed by the three research groups *Mechanics of Materials* (MoM), *User Centred Product Design* (UCPD) and *Intelligent Automation* (IA). The head of VSRC has the position to lead and coordinate the research within the centre, whilst the research group leaders (professor or associate professor) in each group lead the research within each group. Within each research group there are different application areas handled by senior researchers

Meetings are regularly held where each research group leader and the head of VSRC attend. The meetings typically deal with issues like follow up on research progress, discussions of future plans and funding, agreements on joint efforts or projects etc. Furthermore, there are seminars each month where all personnel, connected to research, are invited to discuss and listen to on-going projects presented by researchers. Currently, there is an initiative to form a reference group consisting of industrial research partners. The aim of the reference group is to ensure the industrial relevance of the research carried out.

Fund-raising is initiated in two different ways. One is on the initiative of industrial partners, and the other is on VSRC's initiative. During the last years, structured meetings have been organized to identify good ideas for research, potential industrial partners and funding agencies. The second phase of the process is to contact our industrial partners and present the ideas to see if a mutual interest is at hand. However, with some companies to which there is a close collaboration there are reoccurring discussions of potential research areas and upcoming funding possibilities.

The Knowledge Foundation (KK) is a national funding body that supports research conducted at the new universities in Sweden, which includes University of Skövde. The Knowledge Foundation supports a range of different activities, including research projects, post-doc projects, strategic recruitments,

and education on advanced level. KK also fund a graduate program (APPLY-IT) where VSRC has 2 PhD students enrolled. A special requirement, that the Knowledge Foundation states for all projects funded, is that industrial partners must provide a matching amount of funding, and also that they must actively participate in the research.

The Knowledge Foundation is one of the major funding bodies for VSRC. Researchers within the centre are parts of the so called “KK environment”, which means that their applications for research activities are handled internally at the university (rather than by the Knowledge Foundation centrally). Submission of applications takes place once per year (usually in June). After submission, all applications are evaluated by external reviewers both with respect to scientific quality and to industrial co-production. The review results are summarized by the Faculty of Technology and Natural Science at the university and the steering committee of the KK environment, and are used to decide which projects to approve and how to prioritize among them. The decision is usually announced in October, and approved research activities normally start in the beginning of the following year.

Being a KK environment also means that VSRC have to follow a defined quality assurance process (DNR HS 2012/268-60, *Utvärdering av den vetenskapliga kvaliteten i genomförandet av insatser i KK-miljö*. Translated: *Evaluation of the scientific quality of the implementation of operations in the KK environment*). Furthermore, every year a three year operational plan is generated that covers the upcoming research activities. This plan forms the base for the activities and developments of VSRC and includes upcoming research projects from different funding sources, recruitment needs and collaborations. This assures that a long-term research progress is established. A verification that the quality assurance system works is that VSRC maintain their collaboration with established partners (industry and other universities) in follow-up projects, as well as that VSRC often is recognized as a potential partner by new collaborators. Apart from that, the research is also quality secured by having the ambition to publish in journals with a reputation of good reviewing processes, thus ensuring high quality of the research. The appointment made by AB Volvo, that VSRC is Volvo Global Preferred Academic Research Partner within the area of Virtual Manufacturing from 2009, is seen as a quality recognition of the research undertaken

The following sections include more detailed organisational descriptions of the different research groups.

Mechanics of Materials (MoM)

MoM consists of eight persons; one professor, one associate professor, three assistant professors, and three PhD students, of which one is a licentiate of engineering. The professor is the leader of the group and is the principal supervisor of all PhD students. Each PhD student does also have a second supervisor from the group of senior lecturers.

All PhD students are enrolled at Chalmers University of Technology with Professor Lennart Josefson as their examiner. The PhD students participate in four major follow-ups of their graduate studies each year; two at Chalmers and two at the University of Skövde.

User Centred Product Design (UCPD)

UCPD is organised with a research group leader and researchers. The team consists of senior researchers, PhD students and research assistants. All staff is, besides doing research, also working with education and administrative matters. PhD students have 80% research activity. The level of research of the senior staff depends on the amount of research funding available, but is commonly about 30-50%.

Since approximately 2003 a professor from Loughborough University (UK) is linked to UCPD (on an approx. 25% basis). The main role of this position has been to be main supervisor for PhD students (3 PhDs finalised and one PhD in progress), be involved in discussions about the development of UCPD and contribute in teaching on advanced level. These PhD degrees are awarded at Loughborough University.

PhD students within UCPD are also registered at Chalmers University of Technology (Sweden). This collaboration started in approx. 2002. Up to now one PhD student has been awarded PhD degree within this collaboration, and one PhD student is in progress (planned to be finalised in 2016).

Intelligent Automation (IA)

The Intelligent Automation (IA) group is divided into 6 sub-groups, each responsible for a specific research area with its own leader, senior researchers, PhD students and research assistants. Research within *Lean manufacturing* and *Production maintenance* are established only very recently and recruitment of new senior staff is underway. The level of research of the senior staff depends on the amount of research funding available, but is commonly about 50-80%. PhD students have 80% research activity. Apart from conducting research, almost all of the members in the IA group are involved in education.

The leader in each sub-group is very often responsible for applying project funding or coordinating the applications of projects with other partner groups or institutions. As one of the most active research groups at the University of Skövde, especially in applying for funding within the KK environment, the IA group and the sub-groups maintain an active list of collaborating industrial partners and usually the project proposals are developed with some long-term mutual visions defined together, not based on some one-off ideas.

A3.2 Personnel

Present a general analysis on staff related to personnel tables in section B1.1 (Max 1 page)

According to the staff statistics found in part B1.1, the number of staff was totally 27 persons in VSRC in December 2012. According to the tables in Section B1.1, there are four professors in VSRC. In addition there are two more guest professors, not included in the statistics. Even though these two guest professors are not stated in the tables they have been collaborating with the University of Skövde for many years, mainly as PhD supervisors for students registered at Loughborough University (UK) and De Montfort University (UK). In total, there is one full time professor in VSRC, and five guest professors on part time in VSRC. The part time professors are from Loughborough University (UK), Falmouth University (UK), Michigan State University (US), Karlstad University (SE) and KTH Royal Institute of Technology (SE). The number of guest professors from other universities is a result of a long-term cooperation.

There are three associate professors (docents) and seven assistant professors (PhDs). There are nine persons employed as PhD students who are working 80% of their time with research related activities. In addition, there are three lecturers and three research assistants that are part-time PhD students. In total, there are currently 15 PhD students all together.

The proportion of women in VSRC is low compared to the number of men employed, which is primarily due to the fact that the engineering subject generally attracts more men (about 75 % men started the MSc engineering education 2006/2007, Swedish Higher Education Board: HSV 2008:20 R, p. 46). However, it is prioritized to increase the proportion of women when recruiting new personnel, especially at key positions.

As mentioned in Section A.1, University of Skövde is located in one of the densest industrial regions in Sweden. For this reason, the university found it important to emphasise research within the engineering areas, because of

these areas' strong opportunity to fulfil needs in the surrounding parts of the society, where research is carried out in tight collaboration. As a consequence, VSRC was formed with lower number of staff generally recommended for strong research environments, based on the criteria of the Swedish Higher Education Board (HSV 1998:27 R, pp. 27-28), especially at key positions.

VSRC is actively working on recruiting personnel within key positions. At the moment the following recruitments are in progress:

- A professor within maintenance and reliability has recently been employed and will start at the VSRC in September 2013,
- One of the associate professors is in the process of being promoted to full professor later in 2013,
- 2-3 post-doc position will be opened through an external funded project later in 2013,
- A recruitment process of two assistant professors has recently started,
- There are PhD students, currently finished or are just about to finish their research studies, which will be employed as assistant professors.

These recruitments will make it possible to initiate more research projects and at the same time enable more PhD students to be supervised, which is in line with the ambition for VSRC to grow and to reach the objective to be nationally leading and internationally competitive within the areas of research.

A3.3 Infrastructure, facilities and funding:

Provide a description of the infrastructure of the UoA (not the general infrastructure of the university) that is used to do research (such as laboratories, specific ICT-support; infrastructure for fund raising, collaboration with society, etc.). (Max 3 pages)

All researchers within the Virtual Systems Research Centre (VSRC) are located in the research house *Portalen* at the University of Skövde campus. In general, Portalen enables a great opportunity for initiation of collaboration with society, e.g. since there is a close collaboration with the Industrial Development Centre (IDC), that has its offices located in Portalen as well. IDC is owned by the industrial companies in the region and IDC supports the development of these companies, being funded from the region and EU-projects. Furthermore, Portalen has become a building in which quite many smaller conferences and meetings take place, which further facilitates collaboration. The different

research groups have their own specific equipment and ICT-support. In Portalen there are also laboratory equipment, such as the Lean production laboratory, robot laboratory, PLC laboratory, specimen manufacturing laboratory and tensile test machines.

There is also an on-going work of all the research groups to jointly establish a “Virtual Design and Manufacturing” (VDM) room within VSRC. The VDM room will enable advanced visualization and virtual reality equipment that can support advanced research in intelligent and interactive decision-making support systems, as well as promoting collaborating partners to borrow the room and use the technologies developed from the research to support their real-life decision-making activities.

Some state of the art research demonstrators created in the research projects are available in the building to promote technology as well as the research carried out in the centre.

In terms of ICT-support, VSRC has employed several research assistants, mainly to support the specialist applications (software, prototypes and demonstrators) created by the research groups. This is also an important aspect in the collaboration with society, in which their ICT-departments (e.g. at industrial project partners) may more easily communicate with VSRC upon testing software or prototypes generated in the collaborative research projects.

The funding of each research environment at the university, one of which is VSRC, is based on the degree of external funding granted by the different research groups within each environment. The research projects, as described in A3.1, are exclusively carried out together with the society and are typically externally funded through the Knowledge Foundation, VINNOVA or EU. University of Skövde also internally funds research projects in proportion to the amount of external funding that has been granted.

The different groups have different research laboratories and equipment connected to their specific research, which are described in the following sections.

Mechanics of Materials (MoM)

MoM has access to four tensile test machines with accessories; two of them with hydraulic power supply in the basement.

1. Hydraulic, max load ± 100 kN, hydraulic grips, stroke 250 mm, max rate > 100 mm/s (INSTRON)

2. Hydraulic, max load ± 25 kN, hydraulic grips, stroke 100 mm, max rate > 600 mm/s or an amplitude of 10 mm at 10 Hz (INSTRON)
3. Electro mechanical, max load ± 10 kN, stroke 950 mm, rate < 8 mm/s (LLOYD)
4. Electro mechanical, horizontal, max load 500 N, stroke 300 mm, rate < 0.4 mm/s (SWETEST)

MoM also have equipment for specimen manufacturing (workshop at the university) in the form of milling machines, lathes, band saw for metals, band saw for wood, drilling machines, cold saw, bending machine, folding machine, abrasive machines, belt sanders, welding equipment (both gas and electric), screw compressor, traverse (3000 kg), etc.

Equipment for specimen preparation

1. Seven furnaces with a maximum temperature in the interval 200-800°C.
2. Equipment for handling toxic material, hood, fume cupboards etc.
3. Four microscopes, photo equipment, polishing machines, hardness tester, roughness meter etc.

In the computational perspective, MoM have powerful PC's operating as workstations for simulations. These are equipped with the finite element program Abaqus, Fortran-compilers and MATLAB, enabling development of FE-codes, e.g. user elements and user material models.

User Centred Product Design (UCPD)

UCPD has access to advanced digital human modelling (DHM) software to carry out DHM related research, such as: RAMSIS, JACK and IMMA. There are however no fixed dedicated facilities available for performing experiments for the UCPD group. Some experiments within the cognitive theme of UCPD are performed by building temporary experiment settings, e.g. as described in Thorvald et al. (2010) and Thorvald et al. (2012b) and some experiments are performed in the Lean production laboratory (that enables exercises of manual assembly of small vehicles). No advanced equipment (such as eye tracking, dedicated usability testing software etc.) is available, but rather basic methods such as video recording, manual time and activity tracking have been used up to now. Similarly, for research within the DHM theme there are no fixed lab facilities or sophisticated equipment (such as body scanner, facilities to measure muscle strength and reach-of-motions or motion capture) even though the needs for such equipment are growing in order for the research to advance.

Intelligent Automation (IA)

Apart from equipment such as machine tools and industrial robots to support the research and education in industrial automation in general and advanced manufacturing in particular, the IA group maintains a computer cluster with today 120 connecting computers for running SBO for the research projects. With the Web-service interface, the cluster can be accessed through the internet by some of the collaborating partners, including Volvo and Scania. This cluster is managed by the two IT professionals (research assistants) within the group with the technical support of the IT department of the university.

In terms of research in Lean Manufacturing, the IA group has the access to the Lean production laboratory (a lab that imitates the manual assembly of small vehicles) in Portalen.

A4. Impact, engagement, and co-operation with society

In this section, the UoA describes its efforts to collaborate with society to ensure that research conducted has an impact on society. The section aims to provide the basis for a more holistic and situated evaluation of research impact than is possible from the cases (described in C).

A4.1. Collaboration with society in the UoA

Give an overview of the most promising current collaboration, including primary missions and goals. Describe how current collaboration affects the quality of research. Include evidence and specific details/examples adopted by the UoA rather than broad and vague statements. Do not repeat specific details already included in the case studies (section C). (Max 4 pages)

Most of VSRC's research projects are in close collaboration with industrial companies, local municipalities and/or other governmental facilities, like hospitals. Major Swedish automakers, including AB Volvo, Volvo Car Corporation (VCC) and Scania CV, are long-term collaborating partners in most of these projects. Other manufacturers, like GKN Aerospace (previously Volvo Aero), Electrolux, Arkivator, Daloc, Visi, Coor Industry (previously Euromaint Industry), Kinnarps, Arla, SAP, Daimler, FIAT, Siemens and Ascom, are also examples of collaborating industries. Very often these companies are involved in the early project proposal phases in identifying the research requirements

and planning of the research activities. Steering groups of these projects are also established, including representatives from the collaborating companies.

It can be said that the success of the research within VSRC is one of the key factors that rendered VSRC to be elected as the Volvo Global Preferred Academic Research Partner (by AB Volvo) within the area of Virtual Manufacturing from 2009. In line with this, there are current collaborations with academia and society that are especially successful and promising for the future. The following constellation of collaborators mainly from industry, although not limited to these, gives an overview of the research recently and currently carried out:

GKN Aerospace

With GKN (formerly Volvo Aero), the MoM group develops methods to measure material properties associated with the compressive strength of carbon fibre composites (CFRP). Compressive failure is an important strength-limiting property of CFRP that has to be considered in design. Today, this is done through generous safety margins leading to too heavy and expensive components. The expertise of researchers at GKN, and their ability to fund the project through the NFFP program (Swedish National Aeronautical Research Program) was decisive for the initiation and execution of the study. This work is planned to continue in a new project starting 2014.

Saab Aeronautics

Methods to analyse the delamination strength of CFRP has been developed with Saab through NFFP-funded projects. Delamination decreases the strength of CFRP components and can occur due to defects from e.g. the manufacturing process and/or from transverse impact during the use of the components. This type of damage is especially treacherous since they leave virtually no trace on the surface of the damaged component. The close connection with Saab and their expertise within the area has been important for the quality of the research. For instance, their understanding lead to the identification of some special problems associated with the experimental methods. This lead to a deeper understanding of the properties and more accurately extracted data. These studies are planned to continue in a new project starting 2014. Some initial studies have also been performed on nano-strengthened CFRP. These studies indicate complex results. The maximum stress of the extracted cohesive law is substantially increased with the nano particles added. However, the fracture energy remains un-influenced.

AB Volvo, Scania and DOW

Fatigue properties of adhesive joints and the analysis of fatigue strength of adhesively joined structures are in focus in a current project with AB Volvo, Scania and the adhesive manufacturer DOW. The combination of industrial partners leads to an interest in the connection between the microstructure of the adhesives and the structural properties. Moreover, especially the fatigue threshold value of adhesive joints appears to be sensitive to the properties of the interface with the joined substrates. This gives the MoM group new challenges. A new project is planned to start 2014.

Fraunhofer Institute Bremen

The mixed mode properties of adhesive joints are studies in a mini-project with the Fraunhofer institute, Bremen, Germany. A new test method is developed. The evaluation method puts a focus on the properties of cohesive laws.

AB Volvo

Within cognitive ergonomics, researchers in UCPD investigate the use of mobile information sources in industry and assembly workstation design and its implications on human assembly behaviour. Successful collaboration with AB Volvo in the EU FP6 project MyCar led to UCPD being invited to participate in the EU FP7 project Sense & React which is currently in its first year.

AB Volvo, Scania, and Volvo Car Corporation

A successful collaboration with society in this research area is the IMMA project where all the major vehicle manufacturers (AB Volvo, Scania, Volvo Car Corporation) are involved in one project. This arrangement leads to a wide picture of the research needs, good discussions about plans and priorities, plenty of people from industry involved (likely to lead to larger impact) and a large range of opportunities for case studies and demonstrator developments. Examples of how this affects the quality of research are how the collaboration leads to research results that there is a real need for in industry, as well as the fact that staff from the collaborating companies is co-authors of most of the scientific publications from the research project. Also Small and Medium-sized Enterprises (SMEs) and research institutions are involved in the IMMA project (Virtual Manufacturing Sweden AB, Fraunhofer Chalmers Centre - FCC and Innovatum AB).

AB Volvo and Volvo Car Corporation

There has been a co-operation under a long period of time between VSRC, AB Volvo and Volvo Car Corporation when it comes to simulation-based optimisation (SBO). SBO has over the years been used in many different types of applications, such as production scheduling, production system improvement, knowledge discovery, manufacturing concepts evaluation, and bottleneck analysis. For example, a benchmark application study of using FACTS and SBO technologies to a production system improvement project at Volvo Car Corporation in 2011 has led to the increase of productivity by 36%.

Posten AB

In recent years, the research within VSRC has been expanding significantly to address internal and external logistic problems, which also attract significant amount of funding and support from both industry and international academic networks. In terms of transportation informatics and optimization, the IA group collaborates with Posten AB, the previously state-owned company who is in charge of the postal services in Sweden. Sorting of mail within terminals and transportations of mails between terminals were optimised on a strategic level considering time, cost and emissions. Collaboration has continued within other related areas of scheduling such as staff scheduling at two new terminals at Hallsberg and Rosersberg. Similarly to conceptual simulation modelling for the design of future production lines, staff scheduling system for future terminals can proactively address problems and have huge impact on the costs of such a system.

Avfallshantering Östra Skaraborg (garbage collection and handling)

Another example of new application areas is the scheduling and route optimisation of garbage collection in the region. The iCan system was developed in order to optimize the routes on a daily basis. The system has been implemented and initial evaluations have shown that the system results in significant cost savings (approximately 15-45%) for the organisation.

Skaraborg Hospital

Additionally, the VSRC has been one of the most active research centres in Sweden to apply modelling, simulation and optimisation for healthcare system design, analysis and improvement in the last 10 years. VSRC has successfully collaborated with three important hospitals in Sweden and one hospital in the

US. VSRC has contributed to the design and improvement of the logistic and resource utilization of maternity wards, trauma wards, an emergency department, a radiotherapy clinic and a proton clinic. VSRC is currently involved in two projects, of which one is directly financed by Skaraborg Hospital.

Volvo Car Corporation, Sandvik

Wise-ShopFloor, a three-year project funded by the Knowledge Foundation, is built on a close collaboration with Volvo Car Corporation and Sandvik. The aim of the project is a handy decision support tool to Volvo Car Corporations' operators when dealing with alarm signals, and a web-based tool for Sandvik's engineers when performing knowledge-intensive process planning. Real-world use cases of the collaborating companies have made software prototype and physical testing practical and useful to industrial applications.

A4.2 External collaborations and contributions that support the research within the UoA

Describe supporting key external research collaborations and contributions from actors outside the UoA. Describe facilities and advanced equipment at partner organizations that is used by the UoA. (Max 1 page)

VSRC have some key external research collaborations that contributes with facilities and advanced equipment in order to enable some of the research outcomes. The following collaborators, mainly from industry, give an overview of the support offered:

- **Scania:** Has been supporting VSRC with SEM facilities.
- **AB Volvo:** Has been supporting with a fast servo hydraulic testing machine; environmental testing chamber for experiments at low and high temperatures.
- **Saab Automobile:** Has been supporting with environmental testing chamber for experiments at low and high temperatures.
- **Fraunhofer Institute Bremen (Germany):** Is supporting with a mixed-mode testing machine.
- **Risø lab (Denmark), KTH, Chalmers and Växjö University:** Have been supporting with testing facilities (servo-hydraulic machine and the DIC-system Aramis).

- **Loughborough University:** Enables benchmarking the IMMA development with the DHM tools SAMMIE and HADRIAN that Loughborough University develop.
- **Volvo Group Trucks Technology:** This link has granted VSRC the possibility to access advanced equipment (e.g. supercomputer) and some important data of the company.
- **Volvo Cars Engine:** Supported with hardware (Personal Digital Assistants) and facilities (production line) for testing decision support of OPTIMISE Scheduling System at several occasions.
- **Avfallshantering Östra Skaraborg:** Donated and helped to build the iCan demonstrator - A real truck cabin with a serious game that (a) demonstrates the research results, and (b) is used for the training of new drivers.

A4.3 Innovation activities

The UoA describes the most significant innovations during 2007-2012 making an impact (i.e., a change) on society (Max 3 pages). Examples of innovation are products, designs, processes, methods, etc. The innovations can be realized within the university or by a partner and listed at the end (not included in the three pages) and should not be more than 15.

VSRC has realized some significant innovations during 2007-2012, making an impact on society. The following list shortly describes these innovations.

- **Methods to measure cohesive properties,** as developed by the MoM group, are now used by Saab Aeronautics and the adhesive manufacturer Sika.
- **DHM usage process for industry:** The suggested process for DHM usage in product development processes (Högberg et al., 2008) has been adapted by Volvo Car Corporation for handling ergonomics simulations within production development.
- **IMMA DHM tool:** Development of statistical methods for the consideration of anthropometric diversity. These methods enhance functionality and usability of the IMMA DHM tool by making it “easier to do it right”. The methods are implemented in the IMMA tool. The

basic idea with performing simulations in IMMA is that it is the default manner to perform simulations with several anthropometrically different manikins, rather than the common way in today's DHM tools to simulate with one manikin as default approach.

The DHM tool that is being developed within the IMMA project is still under development but almost already from the start of the project (2009) there have been demonstrator versions of the DHM tool available to the collaborating companies (e.g. the major vehicle manufacturers in Sweden) and hence this represents a degree of impact on society. The major impact will be made when the software is available to the public, which is expected to be approx. 2015 (likely to be available through FCC, Fraunhofer Chalmers Centre).

- **Evaluation of concept for manual assembly information using mobile device:** The use of mobile information sources in manual assembly and the case study reported in the paper shows significant benefits from using mobile information sources as opposed to stationary ones under certain conditions.
- **FACTS Analyser** – first developed in the “Factory Analyses in ConcepTual phase using Simulation” (FACTS) project funded by VINNOVA. FACTS Analyser has demonstrated the enormous potential of “frontloading”, i.e. the use of simulation methods to support the early stages of production systems design, through a new work method that integrates model abstraction, input data management and SBO under an innovative framework. Today, FACTS Analyser is being used by production engineers at Volvo Car Corporation on a daily basis. AB Volvo is considering the same path. With the assistance of Gothia Innovation AB (GIAB), commercialization of FACTS is being considered by the IA group and University of Skövde.
- **iCan** - as a comprehensive software and hardware system for management, planning, optimization, operation, and monitoring of transports and transport missions, is another concrete innovation outcome. The iCan system is generally applicable to all types of transportation problems and is intended to be used in various domains. Examples include, but are not limited to, waste collection, pick-up-and-delivery services, freight transports, etc.

- **iCan demonstrator** - a real truck cabin with a serious game that a) demonstrates the research results, and b) is used for the training of new drivers.
- **Simulation-based Innovization (SBI)** - a multi-objective optimization based innovative knowledge discovery approach that has been applied to several production system design and improvement problems. The idea is new and innovative and has tremendous application potential. It may be concluded that both Swedish and International researchers have showed their recognition of the innovization concept introduced in HSO (Holistic Simulation Optimization), because two best paper awards have been received, one in the Swedish Production Symposium 2012 and the second one at the Learning in Intelligent Optimization conference at Catania, Italy, 2013.
- **SCORE** – a “Simulation-based CONstraint Removal” method to automatically identify bottleneck and improvement potentials, based on the SBI technique, was developed and tested in the FFI-HSO project. The method has to be fully implemented and tested in future work but there are already on-going discussions on whether such a novel method shall be subject for applying for a patent.
- **OPTIMISE - an internet-based SBO platform:** OPTIMISE is a research outcome (software) of several research projects and has been implemented at Volvo Car Corporation together with a cluster of computers used for simulation computations. The OPTIMISE platform is currently used at the company on a daily basis by simulation specialists.

A5. Self-assessment and future development

In this section the UoA should provide a self-assessment of its present opportunities for improvements. What does the UoA aim to achieve, e.g. in terms of activities within the UoA, external networking, interdisciplinary activities, joint publications and funding?

A5.1 Self-assessment of the UoA

Based on the quantitative data (part B) and qualitative assessment above, list strengths, weaknesses, opportunities and challenges (threats) of the UoA and

of the research conducted. Strengths and weaknesses refer to properties of the UoA, whereas opportunities and challenges normally refer to external factors. Propose actions that would improve the quality of the research. Consider both purely academic factors and factors related to cooperation with external partners.

The UoA must grade, on a scale 1-8, and motivate the premises and ability to

- *recruit qualified staff and PhD students,*
- *attract external research funding,*
- *position the UoA internationally.*

Here, 1 means poor and 8 means excellent. Apply a long-term perspective of the strategic planning of the UoA and what priorities that will be made regarding future research (max 10 pages).

Strengths of the Virtual Systems Research Centre (VSRC)

The overall objective within VSRC is to use and develop computer-based models with focus on the development of products, processes and systems. The use of these tools enables testing in a virtual environment that represents the real-world characteristics. Simulation tools used for studying materials strength and fatigue properties, workplace design, product design and system design can be used to proactively identify problems and find innovative solutions at early design stages, and is argued to be important areas of research, both from an environmental and industrial profit point of view but also ethically sound from a societal perspective. Hence, the fact that VSRC performs research within this important area is argued to be a strength.

In VSRC it has been imperative to collaborate with other organisations in academia, industry and society in order to be able to carry out successful research. This approach has led to a network of collaborators both from industry and academia. The research activities have attracted the interest from colleagues internationally, enabling recruiting highly qualified personnel on either full-time or part-time basis. The groups within VSRC have also been able to recruit qualified staff from industry. The recruitments have been successful, i.e. the new employees have blended in nicely in their new environment and are still employed at the university. Furthermore, these persons have a unique knowledge about the problems in the industry as well as contacts to the industry facilitating further collaboration with industry.

VSRC is successfully funded by different funding agencies for the applied research carried out together with the industrial partners. VSRC has been able

to maintain collaboration with established partners (industry and other universities) in follow-up projects, and VSRC is often recognized as a potential partner by new collaborators, which is an indication of the good research quality of VSRC.

The different groups as well as the staff within VSRC are well-known nationally and relatively well known and respected internationally within the specific research areas.

Recently, in 2010, the University of Skövde was granted PhD examination rights in the subject *information technology*, which includes the *industrial informatics* part of VSRC's area of research. PhD students are recruited primarily from Sweden, but VSRC is also attractive for international students, since several international students have been employed in recent years.

Being a part of the KK environment makes it possible to establish a long term strategic plan for future research. As long as the industry finds that the research addressed by VSRC is in line with their interests there are great opportunities to attract funding for future research.

The following sections include a more detailed description of the strengths of the different research groups.

The MoM group has been identified by the Swedish industry as a partner within the field of strength of adhesive joints and delamination of composites. MoM has also delivered good and useful results to the industry. The MoM research group is relatively well known and respected within a limited group of researchers. MoM group is identified by key persons as a group doing good research work. Some of the papers are even copied without proper citations and have been found to be funded by the US National Science Foundation (NSF) based on the results of the MoM group. Furthermore, in terms of funding, the ability to write research applications is good.

Qualified staff is mainly recruited directly from Mechanics of Materials (MoM); only one out of five has a background from another research group. Three of the five have an industrial background which is a strength of the MoM group.

Good research ideas, suitable for PhD students, have been generated by the group to the total of eleven PhD students that have been active during recent years. MoM also has a good cooperation with Chalmers where the PhD students are enrolled. Furthermore, there is collaboration with Fraunhofer, Bremen and earlier with Risø lab, Denmark.

The overall objective within UCPD, to focus on research related to the involvement of user centred aspects in modern product and production development processes, is seen as strength since it is an area that companies

are realising to be a competitive advantage. Aspects such as user inclusion, participative design, design for all, accessibility, maintained or enhanced life quality for all members of society, socially sustainable development, usability, ergonomics, ageing workforce, user experience and pleasurable use are all important matters for companies to consider to stay competitive, but also in order to take corporate social responsibility within the framework of sustainable development.

UCPD has contributed in the development of statistical methods for the consideration of anthropometric diversity. These methods are used for the definition of manikin families in the DHM tool, consisting of strategically defined extreme, but likely, manikins, all with different sizes. UCPD has also developed adaptive regression based methods to define the manikin's other measurements, not defined by the tool user. These methods enhance functionality and usability of the DHM tool by making it "easier to do it right". The methods are implemented in the IMMA tool. The basic idea with performing simulations in IMMA is that it is the default manner to perform simulations with several anthropometrically different manikins, rather than the common way in today's DHM tools to simulate with one manikin as default approach. This is an example of a step towards the research aim to support, or rather guide, designers to handle anthropometric diversity even though they may not be familiar with the complexity of the issue or know the common traps.

The UCPD group's good ability to collaborate with other organisations has led to a network of collaborators both from industry and academia. One example is the VEC (Virtual Ergonomics Centre, www.vec.se) collaboration with Chalmers University of Technology, with joint research projects and PhD education. Another example is the collaboration with Loughborough University within PhD education and the visiting Professor from there.

The DHM related research within UCPD has led to valuable contacts with other DHM researchers in the world. In turn, this has led to that the research leader of UCPD being Associate Editor of the International Journal of Human Factors Modelling and Simulation, and session organiser and chair, and member of scientific committee for international conferences (International Digital Human Modelling Symposium and International Conference on Applied Digital Human Modelling) as well as reviewer of DHM related papers in several international journals.

The cognitive ergonomics theme within UCPD began in 2005 when an industrial PhD student (from Volvo Powertrain in Skövde) was associated to UCPD, where PhD supervision was offered by UCPD. The company had an interest to have research performed within the area of information design and presentation,

within manual assembly of engines. This widened the scope of UCPD into the area of cognitive ergonomics. This theme has then developed further and had led to recruitments of new PhD students, new collaborations and funding for new research projects. It is seen as strength to keep both physical and cognitive ergonomics within the same research group, in order to have a combined knowledge of the human both as a physical/biomechanical and cognitive/thinking being. In the long run the aim is to tighten the research activities within the two themes and incorporate knowledge about cognitive ergonomics into the DHM tools in order to make the tools even more valuable for designers when designing products and workstations with a clear human interface.

The strong focus of the automation group in research and development of Industrial Informatics Tools (IIT) to be used in industry, irrespective of different research areas, represents the key strength of IA and provides the cutting edge for collaborations with companies. The capability of the group in designing and developing new systems, algorithms, methods and processes that can be realized in software, prototypes and demonstrators, has become well-known in Sweden. With concrete results in form of software or prototypes, companies and facilities like hospitals, can effectively test and evaluate the technologies offered by the research and therefore in the long run would produce the trust to continue the collaborations.

Innovation, in terms of combining technologies in an innovative way, represents another key strength of the group. The unique combination of data mining, multi-objective optimization and discrete-event simulation, to extract knowledge about production and supply chain systems, is a good example of innovation and a strength, which also puts IA to connect to the state of the art research in the area of innovation.

Weaknesses of Virtual Systems Research Centre (VSRC)

The applied research within VSRC is project-based, mainly funded by external means and done exclusively together with the society. This causes VSRC to be very dependent on the industrial partners and especially the automotive industry. When the industry faces economic problems, it is sometimes hard to convince the industrial partners that these are problems that need to be resolved. VSRC partners operate on various levels at the companies, but when the partners operate on a relatively low hierarchical level they have a hard time to convince internally about the merits of the research. Furthermore, the majority of the partners are companies in the region connected to the

automotive industry, which could be a problem if the automotive industry is having economic problems. Therefore, the research funding is unsustainable over time with “projects in and projects out” and there is a lack of a steady basic funding for the research within VSRC.

VSRC is also dependent on a limited number of funding agencies and have been unsuccessful in attracting funding from Vetenskapsrådet (Swedish Research Council). In order to spread the risks when it comes to funding, VSRC needs to be more active in applying for funding from other funding agencies, e.g. EU, Vetenskapsrådet, Forskningsrådet för Arbetsliv och Socialvetenskap (Swedish Council for Working Life and Social Research). Another reason to apply for funding from other agencies is that the Knowledge Foundation requires that 50% of the time should be performed by senior researchers which make it hard to fund PhD students.

VSRC has only the right to examine PhD students at the University of Skövde within one area of the research performed within VSRC, i.e. *industrial informatics*, which does not suit some of the research carried out. This makes VSRC dependent on other universities for PhD student registrations and PhD degrees.

The VSRC suffers from a low student volume at the undergraduate programs in engineering at University of Skövde. The low student volume, together with the unsustainable funding, are believed to be reasons that make it harder for the group to recruit senior staff. Furthermore, it is difficult to attract and to recruit highly qualified staff internationally as well as nationally, or it is difficult to make them stay. One clear weakness connected to this matter is that there is only one full-time professor currently active within VSRC since one professor recently left. Furthermore, there is a lack of associate professors and assistant processors.

Apart from the computing resources for optimization and some industrial robots, VSRC generally lacks the manufacturing machinery and equipment to support high-end research within industrial automation. Furthermore, there is a lack of facilities and equipment to perform detailed experiments regarding ergonomics (such as eye tracking, dedicated usability testing software, body scanner, facilities to measure muscle strength and reach-of-motions, motion capture etc.). These are also key weaknesses that indirectly drove the research groups towards mainly performing IIT research. In the long term, without manufacturing machinery, facilities and equipment, this would also prohibit VSRC from offering high-quality education in manufacturing engineering and product design engineering (including ergonomics).

There are only a few examples where the different groups within the centre have worked together in research projects. There might be a risk, if the research areas within the groups becomes more diversified, that there are no room for internal cooperation within the centre.

The area that UCPD attempts to cover is broad and complicated, basically since people comes in all shapes and sizes, behave and think differently and appreciate different things etc. The variety of user needs, conditions and expectations is complicated to handle in design, and even further complicated when one aims to enable the assessment of such issues in virtual design processes, where users are simulated by the use of DHM tools. Hence, the research within UCPD only takes small steps towards its overall objectives, where large areas still are not investigated or not considered at all. This is a weakness that is also related to the youth of the research group as well as the size, spread of competences and resources of the research group.

One area that is basically non-investigated in UCPD's research efforts is research about issues and terms such as user experiences, emotions, affections or pleasure, and how to possibly cater for that area of user diversity in virtual design processes. One PhD student associated to UCPD previously did research within this area, but since the person left the research group after receiving the PhD degree there is a lack of competence in the affective design area. This is a weakness in relation to UCPD's ambition to also do research in this area, with the aim to have an even wider understanding of the challenges for successful user centred design.

Opportunities of VSRC

The title of Volvo Preferred Academic Partner within Virtual Manufacturing grants all the research groups within VSRC the opportunity to be an active partner in any research activities within AB Volvo that involve virtual manufacturing and its related areas. For example, a new Masters programme within Virtual Design and Manufacturing, now under development, has already gained support from AB Volvo.

The close link between the VSRC, IDC, GSP, Volvo Group Trucks Operations (VGTO) and Volvo Cars Engine in Skövde, provides VSRC unique opportunities in starting new research activities that are customised to the needs of the industry in the region. The CEOs are gathered regularly to discuss their strategic research requirements with the leader of VSRC. Such contacts have already brought along concrete outcomes to the IA group within the VSRC: the appointment of a new professor in 2013 and one PhD student within the area of production maintenance.

There are also opportunities to enhance the research activities of VSRC by recruiting more senior researchers, such as a full-time professors and post-docs, as well as recruiting more PhD students. Since European students are able to study free of charge at Swedish Universities there is an opportunity to attract more students to MSc educations that eventually could be a good base for recruiting PhD students, which has also been the case in several recent PhD students' employments. In relation to the restart of the MoM group's Masters programme, in the autumn of 2013, the addition of potential foreign students gives a better basis for recruitments, i.e. offering international recruitment.

VSRC collaborates with other universities, both in terms of joint efforts in research projects as well as PhD educations. Since University of Skövde only got examination rights in one part of VSRC, this collaboration makes it possible to strengthen areas where University of Skövde still not have examination rights. PhD students are enrolled at partner Universities such as: Chalmers University of Technology, Loughborough University (UK) and De Montfort University (UK).

Another opportunity for VSRC is to enhance the collaboration with the current external partners, e.g. Chalmers, Fraunhofer Chalmers Centre, De Montfort University and Loughborough University, in order to gain even further from the good contact already established. Examples of enriched collaboration could be to share expensive and complicated facilities and equipment.

There is also an opportunity to further increase the collaboration between the different groups and research areas within the VSRC. For example collaboration between IA group and the UCPD group, in which the area of simulation-based optimisation, which has been successfully applied to health care and transportations, could be researched regarding product design and ergonomics.

VCRS can enhance its successful approach to collaborate with other researchers and organisations to meet its goals. For example, one opportunity is to collaborate with other research groups at the University of Skövde. This would strengthen the research resources within the VSRC, and may be a successful path for joint funding applications.

Opportunities for new collaborations are University West that has motion capture facilities, and University of Borås which share similar anthropometric diversity consideration research questions as UCPD but related to design of apparels rather than products and workplaces. In addition, a strategic search, both nationally and internationally, for research groups that perform research that neatly links into UCPD's research activities and objectives may be an opportunity for further growth research wise.

With enhanced funding, VSRC would be able to recruit qualified staff, including international recruitment. Newly recruited personnel are often given qualified assignments.

The KK environment gives something close to a steady basic funding. Cooperation within the Västra Götaland Region gives some promises for funding of research in composite mechanics together with the University of Borås. There are some prospects of entering new research areas, e.g. biomechanical problems together with e.g. Sahlgrenska University Hospital and Elos AB (medical technology products).

There are currently significant amount of qualitative and quantitative results generated from the projects which are recently finished (e.g. FFI-HSO) or now in the finalization phase, like WeShare and Wise-Shopfloor. It is expected that the IA group will prioritise the publication of high-quality journals as a key objective using the good results generated from the research projects. Professor Deb's link to the Beacon Center in USA will also bring in new research opportunities.

Professor Kalyanmoy Deb has joined VSRC as a visiting professor (20% employment) since September 2008. Professor Deb is a world-renowned expert in the area of multi-objective optimisation. He ranks 8th in the field of Artificial Intelligence in terms of his Citation Count (<http://academic.research.microsoft.com/RankList?entitytype=2&topdomainid=2&subdomainid=5&last=0&orderby=1>) with 21,457 citations (H-index: 76 (Google scholar)). Since 2013, Professor Deb has moved to Michigan State University in USA and is associated with NSF-supported Beacon Center for the study of evolution in action. He also has a visiting position with Aalto University School of Economics in Finland. Currently he is supervising 3 PhD students at the IA group and one of Professor Deb's PhD graduate students from IIT India, Sunith Bandaru, has spent three months working at the IA group during Feb-May, 2013 and is now applying a Post-doctorate project to continue his research in automated innovization in the IA group. Through Professor Deb, members of the group also got the opportunity to be invited to join some prestigious conferences in IIT, e.g. Dagstuhl Informatics centre.

Challenges (threats)

Small/new universities in Sweden usually receive only limited yearly research funding from the government. If these resources are further distributed to highly diversified research areas, it would further dilute the support to

strategically important areas that could potentially produce high benefits to local societies. Over the past few years, the research funding of the groups within VSRC relies mostly on external funding and almost 100% are project-based. Being without a sustainable form of funding, and only rely on continuous applications for project funding, remain to be the main threat to the research of VSRC. This also indirectly imposes a great challenge for the groups to recruit and keep full-time professors who have high reputation. Another challenge is to be able to identify full-time professors that can be recruited to the groups in VSRC that shares the knowledge area and ambition. Furthermore, some research areas are rare, e.g. the DHM based research in UCPD, at academic or other research institutes in Sweden. An option is to recruit full-time professors from abroad, but a challenge is to offer job openings that are considered interesting enough to establish long term solutions. The lack of sustainable funding also somehow forces senior research staff to spend significantly high portions of their research hours in applying for funding. This in the long run would undoubtedly affect the quality of the research. Furthermore, due to the underfinancing there is too little time available for publishing and visit conferences. The effect of this is that the groups of VSRC may not be visible enough in the scientific community.

The strength that VSRC has tight collaborations with companies could have its downside because it can be easily affected by the general economic conditions in industry. For example, during the recent economic setback since 2008, there have been a lot of lay-offs and company acquisitions, which forced some of the long-term partners to discontinue the research collaborations. Furthermore, the focus on industrially oriented projects can lead to problems with the scientific quality of the research.

A threat when basing research progress on tight collaboration with other organisations is that the arrangement is vulnerable if the collaboration terminates of one reason or the other. For example, the opportunity to enable research results from UCPD to be incorporated into a DHM tool would be strongly reduced if the collaboration with FCC would stop. Another example is the MoM group that is dependent on the goodwill of Chalmers to take on their PhD students.

Grading of the premises and ability to

- recruit qualified staff and PhD students, 4
- attract external research funding, 6
- position the UoA internationally. 5

Part B: Quantitative data of the UoA

In this part of the evaluation package questions and tables are presented in 3 sections which contain quantifiable information about the UoA in support of the statements made in Part A above.

B1: Research environment and infrastructure

B2: Research output

B3: Impact, engagement and co-operation with society

B1. Research environment and infrastructure

B1.1 Staff statistics

Provide information of the number of individuals and full time equivalents (FTE) of staffs' research activity. The 'M' columns show values for men and 'W' for women. The number of individuals refers to Dec 31st each year, whereas FTE is integrated over the whole year. FTE is only presented for 2011 and 2012.

Table B1.1.1. Number of and full time equivalents of permanent research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Professor	2		2		2		3		3		1	
FTE									1.6		0.5	
Assoc. prof. (Lektor and docent)					2		3		3		3	
FTE									1.3		1.4	
Assist. prof. (Lektor, forskare)	6		5		4		5	1	6	1	7	1
FTE									3.5	0.5	2.7	0.3
Lecturer (Adjunkt) ²	1		1		3		2		2		2	
FTE									0.5		1	
Total Individuals	9		8		11		13	1	14	1	13	1
Total FTE									6.9	0.5	5.6	0.3

¹ Professor denotes persons employed as full professors. Associate professor denotes staff qualified to act as principal advisor for PhD students (docent appointment or similar). Assistant professors denote the rest of staff with a PhD.

² Lecturer in this table are also enrolled as PhD-students

Table B1.1.2. Number of and full time equivalents of temporary research staff												
Year	2007		2008		2009		2010		2011		2012	
Staff ¹	M	W	M	W	M	W	M	W	M	W	M	W
Guest profs	1		1		1		1		1		3	
FTE									0.9		0.4	
Adjunct profs												
FTE												
Assistant professor												
FTE												
Post-Docs and research assistants	1		3		3	1	3	1	3		1	
FTE									1.4		0.1	
PhD students ¹	5	2	4	2	4	1	7	2	7	2	7	3
FTE									4.8	1.6	5.2	1.9
Total individuals	7	2	8	2	8	2	11	3	11	2	11	3
Total FTE									7.1	1.6	5.7	1.9

¹ All temporary employed admitted to PhD studies

Table B1.1.3. Other staff supporting research in UoA												
Year	2007		2008		2009		2010		2011		2012	
Staff	M	W	M	W	M	W	M	W	M	W	M	W
Research assistant/ Technician ²	3		3		3		4		6	2	5	1
FTE									3.8	0.9	3.5	0.6
Administrator												
FTE												
Total individuals	3		3		3		4		6	2	5	1
Total FTE									3.8	0.9	3.5	0.6

¹ Fixed term and visiting research staff. Staff is included in the research output as well as in the bibliometric analysis.

² Three of the current research assistants are enrolled as PhD-students

B1.2 Research funding

Sources of research funding and amounts given to the UoA annually during 2007-2012.

Table B.1.2.1. External funding (spent money in t SEK)						
	2007	2008	2009	2010	2011	2012
Research Councils (VR, FAS, Formas etc.)						136
Swedish Foundations (e.g. Wallenberg, SSF, VINNOVA, RJ, KK, Swedish Energy Agency etc.)	7916	6585	4308	10230	11319	10299
EU		1013	781	630	1391	1702
Other public bodies (e.g. county councils, municipalities, etc.)		268		245	227	373
Direct external funding from industry.	1767	952	1058	738	1446	-371
University	3	-7	7		734	443
Others (please specify)						
TOTAL	9686	8811	6154	11843	15117	12582

Table B.1.2.2. Total Research Funding t SEK						
	2007	2008	2009	2010	2011	2012
Total external funding (from table B.1.2.1.)	9686	8811	6154	11843	15117	12582
Faculty funding (governmental funding)	4738	8172	7863	9769	10396	9858
Percentage external funding	67	52	44	55	59	56
Research as competence development	723	505	167	303	728	
TOTAL	15147	17488	14184	21915	26241	22440

B1.3 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during **2011-2012** by permanent research staff.

Table B1.3.1 International networks and collaborations

Number of collaboration institutions ¹	56
Number of research visits abroad (1 week to 1 month duration)	5
Number of research visits abroad (of at least 1 month duration)	3
Number of visiting researchers (1 week to 1 month duration)	6
Number of visiting researchers (of at least 1 month duration)	
Number of funded international research consortia projects	4

¹ Research collaborations given here are limited to those with joint research grants in excess of 100kSEK/year and/or joint publications with the UoA.

B1.3.2 Name of project granted and role of UoA

Project title	Funding body	Role (coordinator/partner)	Start year
MyCar	EU (FP6)	Partner	2006
FUTURA	EU	Partner	2007
GREENet	EU	Partner	2011
Sense & React	EU (FP7)	Partner	2012
EASY- Energy Aware feeding systems	ECO-INNOVERA, Formas	Partner	2012
Erasmus Mundus	EU	Partner	2012

B1.3.3 Other major international activities according to the tradition of the research field¹

	Total No.
Collaboration with Fraunhofer IFAM Bremen: laboratory testing 2011: 2-3 weeks, 2012: 2-3 weeks, 2013: 1 week. 1 journal paper accepted for publishing and 1 test rig built in Bremen.	

¹ Please specify: scientific expeditions, field work etc. and list below including duration
A maximum of five examples in total may be provided.

B1.4. Participation in scientific community

UoAs activities undertaken during 2007-2012 that illustrate high quality leadership interactions with their scientific peers.

B1.4.1 Participation in academic community	Number
Plenary or keynote talk at international conferences	11
Assignment as expert in research councils and foundations	34
Assignment as expert evaluator for position as professor, associate professor (docent) and lecturer	18
Assignment as opponent for PhD thesis	3
Assignment as member of examination board for PhD thesis	17
Assignment as editor or member of editorial board for journal	19
Assignment as reviewer for international journal	130+
Member of national scientific councils	1
Member of international scientific councils	3
Chair of program committee (international conferences)	11
Member of program committee (international conferences)	46

B1.5 Recruitments

Number of recruited research staff, men (M) and women (W) during 2007-2012.

B1.5.1 Recruitments	Number	
	M	W
Recruitments with doctoral degree from another Swedish university	5	1
Recruitments with a doctoral degree from outside Sweden	2	
Recruitment with doctoral degree from own university		
TOTAL	7	1

B2. Research Output

B2.1 Promotions and degrees

This section quantifies the development of scientific staff during 2007 to 2012 distinguishing men (M) and women (W).

B2.1.1. Doctoral degrees awarded and promotion of researchers												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
No. Doctoral degrees	1		1		2	1	3		1			
No. Docent promotions					2		1					
No. Professor promotions					1							
TOTAL	1		1		5	1	4		1			

B2.2 Publications

Publications and other research output achieved during 2005-2012 to provide the publication profile of the UoA.

Table B2.2.1: Total number of scientific publications produced by the UoA. Please specify citation index in each publication list.										
Publication types	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Article in journal, peer reviewed	1	7	6	10	9	16	17	12	78	9.8
Article in journal, not peer reviewed				1	1			1	3	0.4
Article in journal, book review										
Article in journal, review						1	1	1	3	0.4

Book										
Edited book					7	5	6	3	21	2.6
Chapter in book		1	1	2		3	6	5	18	2.3
Conference paper (peer reviewed)	14	13	27	23	23	29	29	28	186	23.3
Conference paper (not peer reviewed)		10							10	1.3
Thesis, doctoral	2	1	2	2	2	2	1		12	1.5
Thesis, licentiate ¹	3	1	1					2	7	0.9
Thesis, master	-	-	-	-	-	-	-	-	-	-
Report		2	1						3	0.4
Other scientific publication	-	-	-	-	-	-	-	-	-	-

¹ Licentiate is a Swedish and Finnish academic degree on graduate level corresponding to circa half a Swedish PhD.

Table B2.2.2. Aggregate publication information										
	2005	2006	2007	2008	2009	2010	2011	2012	Total	Total / Annual average
Total number of publications in DiVA	20	35	38	38	42	56	60	52	341	42.6
Number of publications in Web of Science	2	9	10	12	14	15	17	11	90	11.3
Number of publications in Web of Science, author fractionalized	0.6	6.6	7.8	8.3	8.0	9.8	10.8	5.8	57.6	7.2
Web of Science visibility (percent of publications included)	10%	26%	26%	32%	33%	27%	28%	21%	26%	-
Scopus visibility (percent of publications included)	20%	29%	18%	42%	38%	43%	33%	29%	33%	-
Journals' field normalized impact		0.82	1	1.09	0.96	0.86	0.83	-	0.91	-
Journal Impact Factor		0.82	1.14	1.68	1.34	1.16	1.19	-	1.23	-
Norwegian score	4.2	10.1	12.2	21.5	17.1	29	26.8	31.8	152.7	19.1

Norwegian score fractiona- lized	2.4	7.3	8	14.1	9.4	18.3	17.7	20.8	97.9	12.2
Publica- tions in level 1 journal – Norwegian list		6	4	8	8	12	14	8	60	7.5
Publica- tions in level 2 journal – Norwegian list				3	1	3	3	3	12	1.6
Publica- tions in level 1 conference – Norwegian list	6	4	9	5	7	11	4	14	60	7.5
Publica- tions in level 2 conference – Norwegian list										
Publica- tions in level 1 book publishers		1	1	1			1	5	9	1.1
Publica- tions in level 2 book publishers										

Table B2.2.3. Citation indicators									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Total number of citations	0	101	110	55	30	39	22	-	357
Number of citations, author fractiona- lized	0.0	88.8	93.8	48.4	15.3	22.8	10.8	-	279.9
Citations per publication	0.0	11.2	11.0	4.6	2.1	2.6	1.3	-	4.5
Share of publica- tions not cited	100%	22%	30%	33%	57%	33%	35%	-	38%
Average field normalized citation rate		1.22	2.54	0.71	0.67	0.57	0.74	-	0.92
Share of publica- tions among the 10 percent most cited in the field		0%	40%	11%	0%	0%	0%	-	6%
Share of publica- tions among the 25 percent most cited in the field		43%	60%	22%	14%	8%	14%	-	22%

Table B2.2.4. Authorship									
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Average authors per publication	5	2.7	3	3.5	2.9	2.9	3.2	3.2	3.1
Average countries per publication	1	1.1	1.1	1.3	1.3	1.4	1.5	1.5	1.3

Table B2.2.5. Role of key scholars									
	2005	2006	2007	2008	2009	2010	2011	2012	Total / Annual average
Share of publications by 3 most active authors	30%	46%	42%	63%	64%	75%	85%	75%	65%

Table B2.2.6. Productivity								
	2007	2008	2009	2010	2011	2012	Total	Annual average
Number of publications in relation to total funding (MSEK).	2.51	2.17	2.96	2.56	2.29	2.32	2.44	2.47
Number of publications in relation to FTEs					3.49	3.82	3.64	3.66
Number of citations in relation to FTEs					1.28		0.71	0.64

B2.3 Innovation output

As well as engaging with society through contract research or education, researchers today sometimes patent their findings, commercializing these through multiple routes. Researchers also form companies either based on patents, or other forms of intellectual property e.g. materials, software or experience. These activities, often referred to as ‘innovation activities’, are listed in the tables below for the years 2007-2012.

B2.3.1. Patents¹			
Patent number ²	Short description	Person(s) involved at UoA	Date of registration

¹ Data should match that held in DiVA.

² Awarded patents only, not patent applications.

B2.3.2. Founded companies¹				
Company name	Founder(s) from the UoA	Company type	Date of formation	Current status

¹ Included eligible companies must be a direct result of the university’s research activities and have, or have had, an annual income in excess of 100 kSEK.

B3. Impact, engagement and co-operation in research with society

This section presents activities related to co-operation in research with society and the impact of such activities. It includes the unit’s general approach to enable impact and engagement from its research, and also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B3.1 PhD degrees

The number of doctoral degrees (PhD, etc.) earned within the UoA during 2007-2012 when the awardee has been externally employed. Number of men (‘M’) and number of women (‘W’) are recorded per year.

Table B3.1.1. Doctoral degrees awarded to students externally employed												
	2007		2008		2009		2010		2011		2012	
	M	W	M	W	M	W	M	W	M	W	M	W
Number of doctoral degrees			1				1				1	

B3.2 Major research related co-operation with society

Activities regarding research related co-operation with society should be entered into one of three categories in the table below: Table 3.2.1 lists mobility between academia and non-academic society, such as exchanged lectures with external (non-academic) organisations, the engagement of adjunct professors, and externally financed PhD students in collaborative research projects with partners from industry or other organisations in society; Table 3.2.2 includes the number of publications co-authored with individuals outside of academic institutions, and popular publications aiming at the general public; Table 3.2.3 counts the number of external partners of the UoA separated between SME, large enterprises, and non-industrial partners; Table 3.2.4 summarizes the amount of *in kind* funding from industry and non-industrial organisations in society.

Table 3.2.1: Mobility between academy and society						
	2007	2008	2009	2010	2011	2012
No. of collaborative doctoral students ¹	4	6	6	5	4	3
No. of temporary research positions outside university ²						2
No. of adjunct researchers						

¹Number of doctoral students in the UoA who are financed by non-academic external partners. Note that this does not mean doctoral students who are financed by any non-academic funding body, but students who are financed by external partners to the UoA (e.g. industry or public sector organisations).

²Permanent UoA personnel who migrate from the university to non-academic society

Table 3.2.2: Outreach activities						
	2007	2008	2009	2010	2011	2012
No. of scientific publications with representatives from society (not academia)	5	11	4	9	14	15
No. of popular science publications (popular science magazines, including the internet)				1	1	

Table 3.2.3: Collaboration organizations (please provide description in A4.1.)						
	2007	2008	2009	2010	2011	2012
No. of partners from industry (SME) ¹	11	12	17	16	16	10
No. of partners from industry (non SME)	24	25	28	39	19	20
No. of partners from society excl. industry and academia	5	5	8	8	5	4

¹enterprise with no more than 250 employee and an annual turnover not exceeding 50 M €.

Table 3.2.4: Indirect external funding (in t SEK)						
	2007	2008	2009	2010	2011	2012
Indirect funding from non-industrial organisations in society (in kind ¹)						50
Indirect external funding from industry (in kind) ²	9686	8811	6154	11843	15117	12582

¹value of working hours done by external partner, value of equipment, databases, software, laboratories etc. that external partners provide in joint research projects.

²Indirect external funding is estimated based upon the amount of external funding, which normally is the same amount as the in kind from industry

Part C: Case descriptions

C.1. Impact case

The number of cases required in each submission is two (max.). The case should have been carried out during the period January 1st 2007 to December 31st 2012. Each case must provide details not only of the academic impact e.g. publications in highly ranked journals, but also describe the impact of the excellent research on society.

Table C1.1.2 Template for impact cases (maximum 4 pages)	
Title of case	
Describe and provide evidence of the specific impact, including:	
<ul style="list-style-type: none"> - an explanation of the nature of the impact, - how far-reaching the impact is/who the beneficiaries are, - how significant the benefits are 	
Explain how the UoA research activity contributed or led to the impact, including:	
<ul style="list-style-type: none"> - an outline of what the underpinning research was, when this was undertaken and by whom, - what efforts were made by staff in the unit to exploit or apply the findings or secure the impact through its research expertise, - acknowledgement of any other significant factors or contributions to the impact 	
Provide references to:	
<ul style="list-style-type: none"> - key research outputs evidencing the impact (list of publications, patents etc.), - other external reports or documents, or contact details of a user, that could corroborate the impact and contribution of the UoA 	
Any aspect the UoA wants to highlight	

Impact case 1: Holistic Simulation Optimisation

Sustainability, in terms of “Energy Efficiency” , “Lean”, “Lead Time Efficiency” and other forms of reuse/conservation of resources has become a paramount factor that needs to be considered not only during the operational stage but from the very first day a production system is designed. At the same time, there is an urgent need for the Swedish manufacturing industry to explore strategies and methods to accelerate the industrial efficiency progress and support decision making in order to regain profitability. With this as the core motivation, the FFI-HSO project was started in September 2009, with an aim to explore and develop a new manufacturing management and decision support methodology, or so-called HSO methodology, as illustrated in figure 3, based on the state-of-the-art simulation-based multi-objective optimization (SMO) technology. The very concrete and successful results of HSO can be demonstrated from a business case study completed at Volvo Car Corporation (VCC) in 2011.



Figure 3: HSO framework for manufacturing management and decision support.

In a business case study of the re-design of a components machining line (I5D Cylinder heads), the main objective was to achieve a 20% increase in production capacity but at the same time reduce running cost by 20%. In other words, the challenge was to identify the optimal investment alternatives that could increase the throughput, but simultaneously reduce the running cost as much as possible. The potential of applying the HSO technology, taking into account productivity, financial and sustainability factors for decision-making support, had been proven to be very beneficial for this kind of applications. Unlike many other research case studies, IA got the opportunity to validate the results because the manager of the target plant had decided to implement the

solution proposed from the study. The validation showed that, with an one-off investment cost of 1.6 MSEK (approx. €185 000), overall throughput of the machining line was improved by 20.9% and the cost performance on annual basis was improved by 26.5% and energy consumption reduced by 12-15%. If we consider the definition of productivity as Output/Input, then with the improved output (number of products per year) and simultaneously less input (resources or cost), then the increase of productivity in this case study was actually 36%. Behind this successful case study was an innovative way of embedding many improvement potentials into the simulation model of the production line so that the best combinations are sought and analysed using the algorithms explored in the project. This approach is also unique from a scientific research perspective because, to our best knowledge, using SMO to identify optimal improvements to manufacturing systems has never been proposed. Such a successful case study was also the major motivation for VCC to install the software system, FACTS Analyser, for in-house use of their production managers/engineers since 2012. The good acceptance of the HSO results within VCC can be witnessed by their initiative to nominate the project results to 2013 Volvo Cars Technology Award. For this evaluation, the nomination letter by the Director of Manufacturing Engineering of Volvo Cars Engine is attached.

In terms of scientific contributions, altogether are so far over 35 scientific articles produced from the research related to HSO, wherein 10 of them are published or submitted (4 under review) to international peer-reviewed journals. There are 20 conference papers published in high-ranked conferences within optimization, simulation and/or production engineering. It may be concluded that both Swedish and International researchers have showed their recognition of the innovization concept introduced in HSO, because two best paper awards have been received, one in the Swedish Production Symposium 2012 and the second one at the Learning in Intelligent OptimizationN (LION7) conference at Catania, Italy, 2013.

Selected Publications related to HSO and the impact case

Dudas, C., Ng, A.H.C., Pehrsson, L. and Boström, H. Integration of data mining and multi-objective optimization for decision support in production system development. Accepted to be published in the *International Journal of Computer Integrated Manufacturing*.

Pehrsson, L., Ng, A.H.C. and Stockton, D.J. Industrial Cost Modelling for Multi-Objective Optimisation of Production Systems. Submitted to the *International Journal of Computer and Industrial Engineering*.

Ng, A.H.C., Dudas C. and Deb, K. (2011). Simulation-Based Innovization using Data Mining for Production Systems Analysis. In *Evolutionary Multi-objective Optimization in Product Design and Manufacturing*, L. Wang, A. Ng, K. Deb (eds), Springer, 401-430.

Pehrsson, L., Ng, A.H.C. and Bernedixen, J. (2011). Multi-objective production system optimisation including investment and running costs. In *Evolutionary Multi-objective Optimization in Product Design and Manufacturing*, L. Wang, A. Ng, K. Deb (eds), Springer, 431-454.

Ng, A.H.C., Dudas, C., Boström, H. and Deb, K. (2013). Interleaving Innovization and Multi-Objective Decision-Making for Faster Convergence in Production Systems Optimization. *The 7th International Conference on Learning in Intelligent Optimization (LION7)*, 7-11 January, 2013, Catania, Italy. **(Best long paper award)**

Siegmund, F., Ng, A.H.C., Bernedixen, J., Pehrsson, L. and Deb, K. (2012). Reference Point-based Evolutionary Multi-objective Optimization for Industrial Systems Simulation, *Winter Simulation Conference 2012*, Berlin, Germany.

Ng, A.H.C., Dudas, C., Pehrsson, L. and Deb, K. (2012). Knowledge Discovery in Production Simulation by Interleaving Multi-Objective Optimization and Data Mining. In *Proceedings of the 5'th Swedish Production Symposium (SPS'12)*, Linköping, Sweden, 6-8 November 2012, 461-471. **(Best paper award in Industrial Automation)**

Pehrsson, L. and Ng, A.H.C. (2011). An applied framework for simulation-based multi-objective optimisation within production system development. In *Proceedings of the Industrial Simulation Conference*, 6-8 June, Venice, Italy, 121-128.

2013 Volvo Cars Technology Award

"Holistic Simulation Optimization"

PART 1 RECOMMENDATION LETTER

Nomination letter, VCTA, 2013, Holistic Simulation Optimization

The Holistic Simulation Optimization (HSO) concept is substantially enhancing the prerequisites for decision-making within production systems development and improvement. This technology will definitely contribute to shorten project lead-times and improve the performance of new and updated production lines through its unique combination of optimization and knowledge extraction techniques. The opportunities to evaluate and optimize conceptual production systems towards several conflicting objectives, including investments, running cost and lean buffering in early project phases are really contributing to the creation of competitive production systems for the future. Additionally, the novel algorithms and techniques for automatic detection of bottleneck and identification of improvement potentials have given a competitive advantage for VCCs manufacturing operations.

The HSO technology is made generally applicable and can be used to analyze and optimize a variety of production related problems, thanks to the integrated methods, toolsets and software developed within the project.

The project team has been able to both extend the research frontier and simultaneously transfer technology all the way into real production improvement results and implementation within the company.

I am very happy to nominate the HSO project to the VCTA 2013.

Sincerely,

Hans Haavik
Director Manufacturing Engineering VCE

Impact case 2: Strength of adhesive joints

“Ulf Stigh and his associates at the University of Skövde have done an excellent work covering both experimental and numerical work. The work was conducted within a national research program (NFFP KEKS Cost Effective Composite Structures). The outcome has been of great importance for us both in internal and external programs resolving issues that should have been very hard to deal with otherwise.” Dr Tonny Nyman, Technical Fellow, Saab Aeronautics and Adj Professor, KTH, Tony.Nyman@saabgroup.com, Saab Aeronautics 58188 Linköping, +46 13 183551.

A method to accurately predict the strength of adhesively bonded structures has been developed by the MoM group. Adhesive joining allows for mixed materials and provides a means to decrease the weight of structures by combining lightweight and high strength materials. Weight is related to a number of central issues in the society, e.g. limited oil resources and polluting cars. By decreasing the weight, less oil is used and pollutions are decreased. The development of the method is on-going, but it appears that the strength can be predicted with good accuracy provided fracture of the joint occurs through crack growth inside the adhesive layer. At Saab Aeronautics, this method is used today in research-oriented activities. This is also done in other industries. However, Saab has been able to verify the method by comparisons with full-scale experiments. National and international colleagues have also developed similar methods. However, the almost unique ability of the MoM group is the knowledge on how to measure the properties of an adhesive layer. These methods are today used by e.g. the Risø lab in Denmark (Dr Bent Sørensen), the Fraunhofer institute in Bremen Germany and by Sika, Switzerland (Dr Pierre Jousset, jousset.pierre@ch.sika.com). They write:

“The usage of the research results of Ulf Stigh's group, lead to a significant improvement in the understanding of our results at the Fraunhofer IFAM Bremen. We now obtain more information from our experiments and in the same time we are able to reduce the number of necessary experiments and consequently also the costs for us and our industrial customers and partners. In summary, the research results of Ulf Stigh's group benefit a lot to IFAM, since they can be excellently used for industrial purposes.” (Dr Stephan Marzi, Fraunhofer IFAM Bremen, Germany, stephan.marzi@ifam.fraunhofer.de +49 421 2246-420).

“Ulf Stigh, Anders Biel and their associates have provided reproducible experimental results and could successfully extract material parameters that could be used in numerical simulations. This work was conducted both within an international research program (Futura European project) and within specific orders from Sika to University of Skövde. The outcome is of prime

interest, allowing Sika to provide internal and external support to customers, evaluating the integrity of bonded structures with numerical simulations” (Dr Pierre Jousset, Sika Technology AG, Zürich, Switzerland, jousset.pierre@ch.sika.com, +41 44 4364566).

Ideas on how to model adhesive joints, how these models can be integrated with the finite element method and on how to measure the properties of adhesives in thin joints emerged in the late 80's in a number of papers by Stigh (1987-1989). The finite element technique was developed at the same time at other places in the world and is now available in commercial FE-codes. At the University of Skövde, these methods could be developed into experimental methods to measure the properties (Andersson 1998-2002). Alfredsson and Leffler (1997-2004) developed complementing methods to measure the properties in shear loading. Finite elements were further developed by Salomonsson, Alfredsson and Carlberger (2002-2008). Studies on the effects of alternating load, layer thickness, temperature, and strain rate were performed by Biel and Carlberger (2007-2010). Högberg (2007) developed a method for mixed mode loading. Walander (2013) analysed the influence of temperature based on statistical methods.

Selected papers related to Strength of adhesive joints

Alfredsson KS, Stigh U (1997) A method to determine constitutive properties of thin interface layers loaded in shear. ICF9, Adv Fract Res (Eds. Karihaloo BL, Mai Y-W, Ripley MI and Ritchie RO), Pergamon, Amsterdam, **5**:2667-2674

Alfredsson KS (2003) On the determination of constitutive properties of adhesive layers loaded in shear - an exact inverse solution. Int J Fract, **123**:49-62.

Alfredsson KS, Biel A, Leffler K (2003) An experimental method to determine the complete stress-deformation relation for a structural adhesive layer loaded in shear, In 9th Int Conf Mech Beh Mat, Geneva, Switzerland 2002

Alfredsson KS (2004) On the instantaneous energy release rate of the end-notch flexure adhesive joint specimen. Int J Sol Str **41**:4787–4807

Andersson T (1998) Design of an experimental setup for measurement of adhesive peel properties. MSc Thesis, University of Skövde.

Andersson T, Stigh U (2004) The stress-elongation relation for an adhesive layer loaded in peel using equilibrium of energetic forces. Int J Sol Str **41**:413-434

Biel A, Stigh U (2010) Damage and plasticity in adhesive layer - an experimental study. Int J Fract **165**:93–103

Carlberger T, Alfredsson KS, Stigh U (2008) FE-formulation of Interphase Elements for Adhesive Joints. *Int J Comp Meth Engin Sci & Mech* **9**, Issue 5:288 – 299

Carlberger T, Biel A, Stigh U (2009) Influence of temperature and strain rate on cohesive properties of a structural epoxy adhesive. *Int J Fract* **155**:155-166

Carlberger T, Stigh U (2010) Influence of layer thickness on cohesive properties of an epoxy-based adhesive – an experimental study. *The J Adh* **86**:814–833

Högberg JL, Stigh U (2006) Specimen proposals for mixed mode testing of adhesive layer. *Eng Fract Mech* **73**:2541-2587

Högberg JL, Sørensen BF, Stigh U (2007) Constitutive behaviour of mixed mode loaded adhesive layer. *Int J Sol Str* **44**:8335–8354

Leffler K, Alfredsson KS, Stigh U (2007) Shear behaviour of adhesive layers. *Int J Sol Str* **44**:530-545

Marzi S, Biel A, Stigh U (2011) On Experimental Methods to Investigate the Effect of Layer Thickness on the Fracture Behaviour of Adhesively Bonded Joints. *Int J Adh Adh* **31**:840-850

Olsson P, Stigh U (1989) On the determination of the constitutive properties of thin interphase layers - an exact inverse solution. *Int J Fract* **41**:R71-76

Stigh U (1987) Initiation and growth of an interface crack. *Mechanical behaviour of adhesive joints*, Pluralis, Paris, France, 237-248

Stigh U (1988) Damage and crack growth analysis of the double cantilever beam specimen. *Int J Fract* **37**:R13-18

Stigh U, Andersson T (2000) An experimental method to determine the complete stress-elongation relation for a structural adhesive layer loaded in peel. In: *Fracture of Polymers, Composites and Adhesives* (Eds. Williams J.G. and Pavan A.),ESIS publication **27**:297-306

Walander T, Biel A, Stigh U (2012) An evaluation of the temperature dependence of cohesive properties for two structural epoxy adhesives. In: *Proc 19th Europ Conf Fract*, Kazan, Russia, Aug 26-31 2012

T. Walander (2013) [Cohesive modelling of the temperature dependence of epoxy based adhesives in Mode I and Mode II loading](#). (Lic. no. 2013:08) Chalmers Tekniska Högskola, Göteborg. ISSN 1652-8565

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HÁSKÓLA
ÍSKÓLVE

3A

A close-up photograph of the 'PORTALEN' sign, which is illuminated and mounted on a dark, textured surface. The sign is white with a 3D effect. Above the sign, a wooden panel and a red emergency exit button are visible. Below the sign, a glass window reflects the sky.

3

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Appendices



Rektor

BESLUT
Dnr HS 2012/459-60
2012-12-10

Kvalitetsgranskning av forskningen vid Högskolan i Skövde (1 bilaga)

Härmed beslutar jag att forskningsverksamheten inom identifierade forskningsspecialiseringar vid Högskolan i Skövde ska utvärderas under 2013.

Utvärderingen sker i projektform och benämns *Assessment of Research and Coproduction 2013* (ARC13). Till projektledare utser jag Noël Holmgren, professor i teoretisk ekologi.

En styrgrupp som består av Lars Niklasson, prorektor, Noël Holmgren, projektledare och Anne Persson, dekan för fakultetsnämnden för teknik och natur, utses att leda projektet samt ges mandat att fatta de beslut som är nödvändiga inom ramen för utvärderingen.

Bakgrund till utvärderingen, hur utvärderingen organiseras samt en preliminär tidsplan för projektet beskrivs i bilaga till beslutet (projektbeskrivning).

Det är av yttersta vikt att de administrativa resurser som krävs för att ta fram och sammanställa de efterfrågade kvantitativa data finns tillgängliga. Jag uppdrar därför åt förvaltningscheferna att ha beredskap för det stöd som kommer att efterfrågas.

Beslutet fattas efter föredragning av Malin Pihlström, utredare.

Sigbritt Karlsson
Rektor

Kopia till:

Forskningscentrum för informationsteknologi (utvärderingsansvarig)
Forskningscentrum för systembiologi (utvärderingsansvarig)
Forskningscentrum för virtuella system (utvärderingsansvarig)
Forskningspecialisering framtidens företagande (utvärderingsansvarig)
Forskningspecialisering välbefinnande (utvärderingsansvarig)
Högskoleledningen
Fakultetsnämnden för teknik och natur
Fakultetsnämnden för lärande, hälsa och samhälle
Institutionerna (3)
Förvaltningsavdelningarna (8)



Rektor

PROJEKTBESKRIVNING
Dnr HS 2012/459-60
2012-12-10

Organisering av forskningsutvärderingen vid Högskolan i Skövde 2013

Bakgrund och syfte

Högskolan i Skövde kommer under 2013 att genomföra en kvalitetsgranskning av forskningen inom identifierade forskningsspecialiseringar. Dessa är de tre inrättade forskningscentrumen systembiologi, virtuella system och informationsteknologi samt två forskningsspecialiseringar med inriktning mot framtidens företagande respektive välbefinnande.

Utvärderingen benämns *Assessment of Research and Coproduction 2013* (ARC13) och kommer att göras i nära samverkan med Högskolan i Halmstad och Mittuniversitetet med delfinansiering från KK-stiftelsen.

Syftet med granskningen är att få en utvärdering av nuläget, men också att få förslag till utveckling av forskningen inom de identifierade forskningsspecialiseringarna. Vad utvärderingen bör resultera i är tydligt identifierade mål och strategier för utveckling av respektive forskningscentrum och forskningsspecialisering.

För Högskolans tre inrättade forskningscentrum, d v s systembiologi, virtuella system och informationsteknologi, kommer granskningen att utgöra del av det underlag som, enligt gällande riktlinjer, ska finnas tillgängligt inför styrelsens beslut om centrumens fortsatta verksamhet för den kommande sexårsperioden. För systembiologi och informationsteknologi innebär detta att styrelsen kommer att fatta ett ettårigt förlängningsbeslut i december 2012, eftersom dessa egentligen skulle ha utvärderats redan under 2012. För virtuella system kommer utvärderingen ett år före den första sexårsperiodens utgång.

För de två forskningsspecialiseringar som är under utveckling, d v s de med arbetsbenämningarna framtidens företagande och välbefinnande, kommer underlagen i huvudsak att utgöra grund för arbetet med att identifiera mål och strategier för utveckling.

Tidsmässigt ligger denna typ av utvärdering väl i tiden, eftersom regeringen föreslagit att liknande utvärderingar i någon form kommer att ligga till grund för framtida fördelning av forskningsanslag.



HÖGSKOLAN
I SKÖVDE

Rektor

PROJEKTBESEKRVNING

Dnr HS 2012/459-60

2012-12-10

Organisering

Projektet med att utvärdera Högskolans forskning leds av en styrgrupp med stöd av avdelningen för ledningsstöd. Styrgruppen ansvarar för tidsplan och anvisningar till de enheter som ska utvärderas, d v s de fem inrättade respektive tentativa forskningscentrumen, samt även för koordinering av processen och löpande information till berörda enheter och avdelningar på Högskolan.

Styrgruppen består av:

Noél Holmgren, projektledare

Lars Niklasson, prorektor

Anne Persson, dekan för fakultetsnämnden för teknik och natur

Malin Pihlström, utredare/projektkoordinator (adjungerad)

Anne-Louise Elowson, utredare/projektstöd (adjungerad)

Inför själva utvärderingsarbetet har tre arbetsgrupper tillsatts för att ta fram de kriterier och indikatorer som ska ingå i självvärderingarna:

Arbetsgruppen för bibliometriska
indikatorer

Lisa Grönborg, bibliotekarie
Krister Johannesson, bibliotekarie

Arbetsgruppen för vetenskapliga
kvalitetsindikatorer

Noél Holmgren, projektledare
Stefan Tengblad, professor i företagsekonomi
Tom Ziemke, professor i kognitionsvetenskap

Arbetsgruppen för
samproduktionsindikatorer

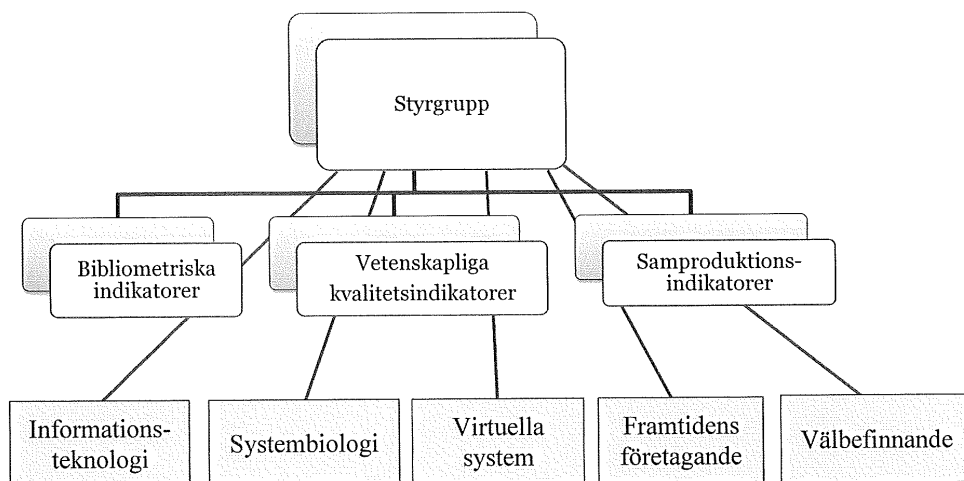
Noél Holmgren, projektledare
Anna Syberfeldt, lektor i automatiseringsteknik
Leif Pehrsson, doktorand
Lars Niklasson, prorektor

Eftersom Högskolans forskningsutvärdering sker i nära samarbete med Högskolan i Halmstad och Mittuniversitetet samråder respektive lärosätens styrgrupper och arbetsgrupper regelbundet för att koordinera arbetets gång och stämma av de gemensamma indikatorer som ska tas fram för utvärderingen.



Rektor

PROJEKTBEKRIVNING
Dnr HS 2012/459-60
2012-12-10



Den aktuella utvärderingen av forskningen finansieras till viss del av KK-stiftelsen och till viss del av Högskolan. I Högskolans budget för 2013 finns medel avsatta för att koncentrerat kunna arbeta med framställningarna av självvärderingarna under våren 2013.

De fem utvärderingsenheterna och huvudansvariga för respektive enhet kommer att vara:

Forskningscentrum informationsteknologi	Björn Lundell, bitr. professor i datavetenskap Jessica Lindblom, lektor i kognitionsvetenskap
Forskningscentrum systembiologi	Björn Olsson, lektor i bioinformatik
Forskningscentrum virtuella system	Josef Adolfsson, adjunkt i automatiseringsteknik
Forskningsspecialisering framtidens företagande	Stefan Tengblad, professor i företagsekonomi
Forskningspecialisering välbefinnande	Ingrid Bergh, bitr. professor i omvårdnad



Rektor

PROJEKTBEKRIVNING
Dnr HS 2012/459-60
2012-12-10

Beskrivning av utvärderingen

Projektet med att utvärdera Högskolans forskning kan delas in i fyra faser: (I) datainsamling, (II) självvärdering, (III) extern granskning och (IV) rapportering.

Datainsamling: Med början under december 2012 kommer Högskolan att börja insamling av grunddata (exempelvis publiceringar och antal forskare per grupp) för respektive specialisering. Denna insamling kommer att pågå även under början av 2013 och då också omfatta de indikatorer som har identifierats av de tre arbetsgrupperna. Stöd från berörda administrativa enheter för att ta fram och sammanställa kvantitativa data kommer att behövas under denna period.

Självvärdering: Utifrån anvisningar från styrgruppen, baserade på arbetsgruppernas identifierade indikatorer påbörjas utvärderingsenheternas arbete med att ta fram en självvärdering.

Extern granskning: För att få ett utifrånperspektiv på forskningen kommer fem så kallade expertpaneler att tillsättas under våren 2013. Varje panel består av fem internationella forskare med kunskap och kännedom om den forskning som är specifik för respektive utvärderingsenhet. Även här sker en koordinering med Högskolan Halmstad och Mittuniversitetet. Expertpanelerna granskar under sommaren 2013 utvärderingsenheternas rapporter samt de kvantitativa data som samlats in. Vid ett platsbesök på Högskolan i Skövde under tidig höst 2013 kommer expertpanelerna att diskutera såväl nuläge som framtida utveckling med Högskolans ledning och företrädare för respektive specialisering.

Rapportering: Avslutningen av forskningsutvärderingen består av den sammanfattande rapport som Högskolans ledning kommer att skriva utifrån de resultat som utvärderingsenheternas självvärderingar och expertpanelernas rapporter har gett.

Relevanta dokument och en tidsplan som uppdateras löpande kommer att läggas upp på en Scio-sida benämnd ARC13.



Rektor

PROJEKTBEKRIVNING
Dnr HS 2012/459-60
2012-12-10

Preliminär tidsplan

Fas	Datum	Händelse	Ansvarig
I	2012-12-10	Rektorsbeslut om utvärderingen	Utredare
	December 2012	Insamling av grunddata (t ex antal forskare och publiceringar)	Utvärderingsenheterna, förvaltningsavdelningar
	2012-12-20	Förslag på indikatorer klara	Arbetsgrupperna för bibliometri, samproduktion resp. vetenskaplig kvalitet
	2012-12-20 till 2013-01-11	Remiss av indikatorer och kriterier till berörda	Styrgruppen
	2013-01-15	Indikatorer för utvärderingen samråds och bestäms tillsammans med HH och MiUN	Gemensamma styrgruppen (HiS, HH, MiUN)
	2013-01-25	Fastställande av anvisningar till utvärderingsenheterna	Styrgruppen
	2013-03-06	Slutdatum för insamling av kvantitativa data enligt fastställda indikatorer	Berörda förvaltningsavdelningar, utvärderingsenheterna
II	2013-05-31	Självvärdering inkl. SWOT-analys klar	Utvärderingsenheterna
III	Sommaren 2013	Externa expertpaneler granskar självvärderingarna	Externa expertpaneler
	Början av september 2013	Platsbesök av expertpanelerna	Styrgrupp, Högskolans ledning
	2013-10-18	Rapporter från de externa expertpanelerna	Externa expertpaneler
IV	Oktober-november 2013	Sammanställning och reflektion kring expertpanelernas rapporter samt avstämning med utvärderingsenheterna	Styrgruppen
	2013-12-13	Slutlig rapport färdig	Styrgruppen
	Mitten av december 2013	Återkoppling till hela organisationen	Högskolans ledning



Rektor

BESLUT
Dnr HS 2012/459-60
2012-12-13

Kvalitetsgranskning av forskningen vid Högskolan i Skövde - komplettering

För utvärderingen av identifierade forskningsspecialiseringar vid Högskolan i Skövde under 2013 (*Assessment of Research and Coproduction, ARC13*) ska styrgruppens sammansättning vara:

Lars Niklasson, prorektor

Noél Holmgren, professor i teoretisk ekologi

Anne Persson, dekan för fakultetsnämnden för teknik och natur

Ali Kazemi, dekan för fakultetsnämnden för lärande, hälsa och samhälle

En representant för Studentkåren

Styrgruppen ska leda utvärderingsprojektet och jag ger styrgruppen mandat att fatta de beslut som är nödvändiga inom ramen för utvärderingen. Projektledare är Noél Holmgren.

Beslutet fattas efter föredragning av Malin Pihlström, utredare.

Sigbritt Karlsson

Rektor

Kopia till:

Forskningscentrum för informationsteknologi (utvärderingsansvarig)
Forskningscentrum för systembiologi (utvärderingsansvarig)
Forskningscentrum för virtuella system (utvärderingsansvarig)
Forskningsspecialisering framtidens företagande (utvärderingsansvarig)
Forskningspecialisering välbefinnande (utvärderingsansvarig)
Högskoleledningen
Fakultetsnämnden för teknik och natur
Fakultetsnämnden för lärande, hälsa och samhälle
Institutionerna (3)
Förvaltningsavdelningarna (8)
Studentkåren



Board of Assessment of
Research and Coproduction

Skövde, 28th May 2013

Instructions to the experts of ARC13

Assessment of research and coproduction 2013 (ARC13) aims at identifying strong areas of research and successful research constellations in the broad spectrum of research at *University of Skövde*. As such, ARC13 will provide means to strengthen the quality of the scientific activities at the university by offering reliable background material for future strategic decisions. The evaluation will also support the Units of Assessment (UoAs) in their work on formulating plans for future research. The evaluation is aimed at assessing performance and prospects of the Unit of Assessment as a whole, not individual scientists. The reports and presentations from the UoAs (written and oral) on their own work constitute the basic material for the evaluation.

Objectives and criteria of the evaluation

The research of the University is organized in research centers and research specializations (named UoAs in ARC13) with a relatively heterogeneous research structure, in which research of diverse character is conducted. Each UoA has been assigned an expert panel. In those cases where research at different UoAs are sufficiently related, have these been grouped together to represent a research area that can be evaluated by one expert panel. The expert panels are constituted by both national and international experts in the field of their UoA and should work as a group to attain a collective assessment, making use of the complementary expertise among the members.

The expert panels are asked to assess the quality of research and collaboration in research of the UoA in a national and international perspective. In particular, the panels are asked to identify strong research and research with potential to grow strong. The evaluation does not intend to compare the UoAs at *University of Skövde* with each other. Instead, it aims at probing the standing of the UoA in national and international perspectives, reflecting the quality and potential of each UoA compared to that of research groups at other universities involved in the same research field. The quality rating applies to the research and collaboration presented to the panels, which may not include all activities.

The report from the expert panel should be organized under the following headings:



Board of Assessment of
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1. General assessment of the UoA

Give a brief account of the overall impression of the research conducted in the UoA.

2. Quality of research

Quality of research includes the degree of international interest (reach) and the impact to the scientific community (e.g. in terms of citations), and publications in leading journals, conference proceedings and/or monographs. It is founded on the reputation and position of the unit within the community of researchers. The quality is assessed on the basis of the ability of the unit to achieve and present clear scientific analyses and new results. The assessment reflects the position of the unit in relation to the frontier of research.

3. Productivity

Productivity relates to the total volume of scientific publications of the unit. The quantification of production is evaluated by means of bibliometric indicators. Productivity includes also number of licentiate and PhD degrees awarded, and promotions of docents and professors. Productivity and its impact should be judged in relation to the number of researchers and their time available for research at the UoA.

4. Research environment and infrastructure

Comment on the research environment, its organization, the constitution of staff, its resources and their activities. Comment on the infrastructure, e.g. in terms of it being adequate and sufficiently available. Also comment on the research environment with respect to issues like diversity, synergies, multi- and interdisciplinary activities, outreach, demographic, gender profile and leadership. The research environment and infrastructure can be distributed, i.e. collaborators may provide key infrastructure. If this is the case, please comment on this and the research environment's ability to make use of these external resources.

5. Networks and collaborations

Comment on the extension, quality of, and amount of collaboration in national and international academic networks. To what degree are academic partners integrated and contribute with their competence to joint research?

6. Coproduction and external cooperation

Comment on the extension and quality of national and international collaborations with society except academia. To what degree are non-academic partners integrated and contribute with their competence to joint research? Evaluate the importance of coproduction



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and infrastructure provided by partners. Does the coproduction and cooperation improve the conditions for and the quality of the research?

7. Impact

Comment on the impact of UoA research on society. Specifically evaluate the significance, the reach and the benefits of the impact cases presented by the UoA.

8. Strategies and plans for development of the UoA

Assess the visions, goals and strategies of the UoA as well as their feasibility of realization and prospect for success. Comment on impressions of junior faculty activities. Comment on the UoA's development potential.

9. Experts views on potential and recommendations for development

Give recommendations for further improvement of any aspect of the UoA with relevance for quality of the research.

10. Other issues

Comment on other issues.

Grading the research

Comment on the quality of the research from a national and international perspective, with emphasis on identifying strong research and successful constellations. Rate the quality of the research according to the scale given (insufficient to excellent) for the aspects under heading 2-8 above. The table "Grading scale" (see attachment) suggests criteria for the grades "Excellent", "Very Good", "Good" and "Insufficient". The evaluation is done for different subject areas with perhaps different views on what constitutes appropriate criteria for these levels. The criteria table should therefore be considered as suggested criteria. If you feel that the criteria need to be modified for the specific research field that you are evaluating, then you are welcome to do such a modification as long as you document and motivate it in your report.

The following expressions for the rating of quality of research should be used:

Excellent - Excellent in an international perspective.

Very good - Very high quality that attracts wide national and international attention.

Good - Attracting national attention and possessing international potential.



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Insufficient - The research is insufficient and publications have not gained wide circulation or do not receive national and international attention. Research activities should be revised.

In some cases, research of very high quality may not have been published outside of a national context due to traditions in the research field or within the research group. If you see examples of such research that should have been made available to the international research community, then please comment on this.

In all cases, the grading is for the UoA as a whole and you must decide on what grade that best describes the UoA. You are welcome to comment on individual research groups within the UoA if you feel that they warrant special attention, e.g. if they perform better than the overall UoA.

Grading scale

Attachment 1

Excellent	Quality	Productivity	Infrastructure	Collaborations	Coproduction	Impact	Renewal
	Wide international attention, most prominent channels, internationally leading research.	Very high number of PhDs, promotions, and publications in relation to UoA resources. The emphasis is on the number of publications.	Leadership, constitution of staff, activity, and ability to attract external funding is excellent in all aspects.	The national and international collaboration is wide and relevant with very high quality partners. Academic partners that contribute to the research.	The collaboration with very high quality partners is wide and relevant regarding partner contribution to joint research. The research has high value with strategic importance for the external partners.	The research has international reach of high significance to society.	Strong, clear visions and realizable strategies. Very promising junior faculty activities.
Very Good	Quality	Productivity	Infrastructure	Collaborations	Coproduction	Impact	Renewal
	International attention, recognized channels, nationally leading research.	Above average number of PhDs, promotions, and publications in relation to UoA resources. The emphasis is on the number of publications.	Leadership, constitution of staff, activity, and ability to attract external funding is very good in most aspects.	The national and international collaboration is wide and relevant with high quality partners. Academic partners that contribute to the research.	The collaboration with high quality partners is wide and relevant regarding partner contribution to joint research. The research has a high value for the external partners.	The research has international reach of significance to society.	Clear visions and realizable strategies. Promising junior faculty activities.

Grading scale

Attachment 1

	Quality	Productivity	Infrastructure	Collaborations	Coproduction	Impact	Renewal
Good	National attention, recognized channels, near the research front.	Average number of PhDs, promotions, and publications in relation to UoA resources. The emphasis is on the number of publications.	Leadership, constitution of staff, activity, and ability to attract external funding is satisfactory in all aspects.	The collaboration is wide and relevant. Academic partners contribute to some extent to the research.	Relevant collaboration partners contribute to the research. The research has value for the external partners.	The research has national reach of some significance to society.	Visions and strategies need some development. Sufficient junior faculty activities.
Insufficient	The research is insufficient and reports have not gained wide circulation or do not receive national and international attention.	Clearly below average number of PhDs, promotions, and publications in relation to UoA resources. The emphasis is on the number of publications.	Leadership, constitution of staff, activity, and ability to attract external funding is clearly unsatisfactory in several aspects.	The collaboration is insufficiently developed.	The collaboration is insufficiently developed.	Lack of reach, or minor significance of research to society.	Unrealistic or lacking visions and strategies.



Assessment of Research
and Collaboration 2013

Description of bibliometric indicators in the ARC13

Short description of method

Records were retrieved from DiVA on the bases of the unique author ID. These records were used for publication counts and for calculation of Norwegian scores. To calculate the Norwegian scores the records were matched automatically by ISSN numbers as well as journal and publisher names. Records that had not been matched were controlled manually.

The unique Web of Science identifiers in the records were used for searching out and download records from Web of Science directly from the web interface. The records from Web of Science were used for citation counts and counts of authors and countries.

Normalized indicators were calculated by the use of data from the Karolinska Institute bibliometric system. The system does not contain the conference indexes of Web of Science. Therefore, the normalized citation indicators are based on a smaller share of the publications than the citation indicators. Also the journal impact factor was based on this data.

Table B2.2.1: Total number of scientific publications produced by the UoA

The number of publications in DiVA published 2005-2012 of the following document types:

- Article in journal, peer reviewed
- Article in journal, not peer reviewed
- Article in journal, book review
- Article in journal, review
- Book
- Edited book
- Chapter in book
- Conference paper (peer reviewed)
- Conference paper (not peer reviewed)

Thesis, doctoral
Thesis, licentiate
Report

Table B2.2.2. Aggregate publication information

Total number of publications in DiVA

The total number of publications in DiVA published 2005-2012 of the document types listed above.

Number of publications in Web of Science

The number of publications in Web of Science published 2005-2012 (articles, reviews, letters, proceeding papers, editorials, letters, books and book chapters included).

Number of publications in Web of Science, author fractionalized

The author fractionalized number of publications in Web of Science is the sum of the analyzed unit's share of authors of the retrieved publications from Web of Science.

Web of Science visibility (percentage of publications included)

The indicator is the share of the total number of publications in DiVA that is indexed in the Web of Science.

Scopus visibility (percentage of publications included)

The indicator is the share of the total number of publications in DiVA that is indexed in Scopus.

Journals' field normalized impact

The journals field normalized impact gives an indication of the impact of the journals in which the unit has been publishing. For each publication the journal's average field normalized citation rate over a 3 years period is calculated. An average is then calculated for all of the journals. A value of e.g. 1.2 means that the unit has published in journals which are cited in average 20 % over the respective field norms. Hence, the indicator shows the average citedness of the journals of publication.

Journal Impact Factor

The Journal Impact Factor is the average impact factor of the journals in which the unit has been publishing.

Norwegian score

The Norwegian score is calculated by giving the publications a score according to publication type and level in the Norwegian list of publishers. The levels are constructed so that 20 percent of all publications in each research field belong to level 2 in the system.

Scores according to the Norwegian system:

Publication type	Level 1	Level 2
Article in journal or series	1	3
Article in anthology	0.7	1
Monograph	5	8

List of journals, series and publishers: <http://dbh.nsd.uib.no/kanaler/?search=advanced>

Norwegian score, fractionalized

The fractionalized Norwegian score is the sum of the analyzed unit's share of the Norwegian score.

Publications in level 1 journal – Norwegian list

The number of articles or review articles that has been published in journals or series classified into level 1 in the Norwegian system.

Publications in level 2 journal – Norwegian list

The number of articles or review articles that has been published in journals or series classified into level 2 in the Norwegian system.

Publications in level 1 conference – Norwegian list

The number of conference papers that either has been published in journals or series classified into level 1 in the Norwegian system or by publishers classified into level 1.

Publications in level 2 conference – Norwegian list

The number of conference papers that either has been published in journals or series classified into level 2 in the Norwegian system or by publishers classified into level 2.

Publications in level 1 book publishers

The number of books or chapters in books that has been published by publishers classified into level 1 in the Norwegian system.

Publications in level 2 book publishers

The number of books or chapters in books that has been published by publishers classified into level 2 in the Norwegian system.

Table B2.2.3. Citation indicators

Total number of citations

The total number of citations in Web of Science to publications published 2005-2011.

Number of citations, author fractionalized

The author fractionalized number of citations in Web of Science is the sum of an analyzed unit's share of citations to publications published 2005-2011.

Citations per publication

The average number of citations per publications for publications from 2005-2011.

Share of publications not cited

The indicator expresses the share of publications with no citations at the time for the analysis.

Average field normalized citation rate

The average field normalized citation rate gives an indication of the citedness normalized to field, year of publication and publication type. A value of e.g. 1.2 means that the unit is cited in average 20 percent over the respective field norms. (2005-2011)

Share of publications among the 10 percent most cited in the field

The indicator shows the share of publications among the 10 percent most cited compared to publications within the same field, of the same document type and categorized into the same subject field. (2005-2011)

Share of publications among the 25 percent most cited in the field

The indicator shows the share of publications among the 25 percent most cited compared to publications within the same field, of the same document type and categorized into the same subject field. (2005-2011)

Table B2.2.4. Authorship

Average authors per publication

The average number of authors per publication for publications indexed by Web of Science.

Average countries per publication

The average number of unique countries per publication for publications indexed by Web of Science.

Table B2.2.5. Role of key scholars

Share of publications by 3 most active authors

The indicator shows the share of publications in DiVA authored or co-authored by the 3 authors with the most publications during the analyzed time period, i.e. 2005-2012



BACK ROW FROM THE LEFT: Björn Lundell, Lars Dencik, Moyra McDill, Diane H Sonnenwald, Kari Lilja, Carmen Molina-Paris, Anna Saran, Noël Holmgren, Björn Olsson

4TH ROW: Hillar Loor, Jessica Lindblom, Ingrid Bergh Katri Vehvilainen Julkunen, Jerome Bickenbach, Hans-Georg Stork, Stefan Tengblad, Thomas Andersson, Josef Adolfsson, Eva Akersten

3RD ROW: Anna Billing, Malin Pihlström, Nancy Russo, Erik Proper, Parvez Haris

2ND ROW: Christian Helms Jørgensen, Viggo Tvergaard, Heiner Bubb, Sighbritt Karlsson, Peter De Ruiter, Julian Leslie, Pekka Abrahamsson, Costis Kompis, Anne Persson

FRONT ROW: Celeste Wilderom, Siau Ching Lenny Koh



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