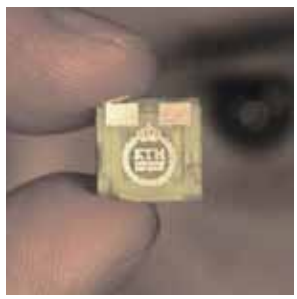
ROYAL INSTITUTE
OF TECHNOLOGY

RAE2012



KTH RESEARCH ASSESSMENT EXERCISE 2012

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Production: KTH University Administration
Layout and Artwork: JG Communication
Printing: E-Print, Stockholm. December 2012
Photo: Nicklas Roxhed/Stefan Braun, Pernilla Josefsson, KTH photo archive: Jann Lipka; Bengt Alm; Håkan Lindgren; Lars Nyman; Christer Gummesson
ISBN: 978-91-7415-199-2

FOREWORD

"Excellence in research for the benefit of humankind and the society of tomorrow."

KTH conducted the first comprehensive research assessment exercise in its history in 2008. The aims were to identify excellence and leadership within the research base that could be strengthened, as well as opportunities for improvement in order to strengthen the international competitiveness of KTH. The present report summarizes the outcome of the 2012 Research Assessment Exercise, RAE2012, which has similar aims to the one conducted in 2008. This exercise has helped KTH determine to what extent the KTH strengths are growing towards our common vision and how previously identified weaknesses have improved. The results continue to be extremely positive for KTH and will provide a basis for the formulation of the KTH strategy for the next four years. We at KTH will continue to focus on strengthening our research base consistent with our ambitions for being one of Europe's top technical universities.

Stockholm, December 2012

Professor Peter Gudmundson
President, KTH Royal Institute of Technology

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PREFACE

"KTH Royal Institute of Technology is an engine for the knowledge, creativity and competence for the benefit of society. As long as its research base is vigorous and healthy and its researchers can pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems for the benefit of society."

The responsibilities of a technical university are many and complex. Such a university should contribute to knowledge and education as well as to society by fostering excellent basic and applied research in a host of fields – and by building relationships between these approaches and fields. A technical research university has a particular responsibility to transfer its research findings to, and interact with, industry and society when executing its strategy. This cannot be taken for granted and, at every strategic decision point, the route that leads to the highest possible level of quality must be chosen.

For this reason, in 2008 KTH performed an extensive international review of its entire research base. The 2008 Research Assessment Exercise showed overall that KTH was considered to be at the forefront of technology development and academic leadership in over half of its research bases. In addition to this, the industrial interactions and innovative performance of its researchers were viewed as excellent. The expert panels invited to KTH in 2008 also highlighted some weaknesses such as a lack of vitality in some ageing research groups and the size of some groups were considered too small to be able to achieve sufficient international visibility. RAE2008 also pointed toward some development issues regarding the overall structure at KTH, such as creating more incentives for excellent basic research and enhancing the available support for experimental infrastructure.

Following the recommendations of these expert panels, between 2009 and 2011 KTH has focused on the consolidation of research efforts in key areas of strength such as materials sciences, energy, transport, information and communication technologies, and life science technology. The internal research resource allocation system was modified to take into account the degree of external financing and citations in addition to the previous production of licentiate and doctoral degrees. In addition, another part of the faculty resources was focused more clearly on prioritized areas of strategic importance to KTH. In addition, KTH has introduced a 'tenure track' system for recruitment of faculty. The main focus of new faculty recruitment is now on young

researchers who can proceed towards higher academic positions through a clear career track, supported by stable basic funding. These changes were made to improve international visibility and to strengthen the KTH brand in these areas, thus paving the way for true international leadership.

Following in the footsteps of the 2008 exercise, RAE2012 has once again performed an extensive international review of the entire KTH research base as it stands today. Through this exercise it will become clear to what extent KTH strengths are growing towards our common vision and how previously identified weaknesses have improved. The basic structure of RAE2012 is similar to that of 2008, except for a few modifications aimed at strengthening a holistic view of the KTH research base. First of all, RAE2012 focuses on the quality of the research output, the social and economic impact of the research and engagement with society, as well as the quality of the research environment.

During the spring, all members of the faculty were involved in the compilation of self-evaluation 'packages' that described the strengths and achievements of their research. The impact from their research and their engagement with society were also articulated, as well as the sustainability and vitality of their research environments. As a part of the preparation for RAE2012, KTH collected all research publications between 2004 and 2011 into a large searchable database, entitled DiVA, which was used as the basis for conducting a comprehensive bibliometric analysis of the 47 research units assessed. Also, CVs were collected for all research active staff.

In June, 101 international experts visited KTH to review the university's research performance. These experts visited all 47 research units over four days, meeting senior faculty, upcoming faculty and research students. After these visits the experts submitted reports, providing a written evaluation of each research unit.

The present report presents a summary of the lessons learned in the RAE of 2008, it goes on to review the quantitative data collected in the evaluation packages, and provides summaries of the assessment reports from the expert panels. The bibliometric analysis is also reported. Findings at the KTH level are also put forward. Information gathered during this process is being used to steer the development of the KTH strategic plan for 2013-2016. It is also providing input for the subsequent strategies of KTH schools.

Professor Björn Birgisson
Vice President for Research
KTH Royal Institute of Technology

EXECUTIVE SUMMARY

The 2012 Research Assessment Exercise, RAE2012, identified a number of strategic and structural strengths at the university level, as well as some weaknesses. The general strength of KTH is the overall high quality of its research outputs, with 22 out of 47 units of assessment (UoAs) having research output quality that is world-leading for the majority of the unit. Similarly, 24 out of the 47 units were assessed as having outstanding impact and engagement with society for the majority of the UoA. However, only 16 out of the 47 units were assessed as having the vital and sustainable environment conducive to producing research of world-leading quality for the majority of the UoA.

The units with the best performance have a good balance between producing quality research with high impact on society and a healthy age and competence profile with both established and young faculty, as well as sustainable high quality research infrastructure and facilities. The bibliometric analysis confirmed the excellent performance of those research areas which have a strong tradition in publishing in peer reviewed international journals. Importantly, the bibliometric analysis highlighted the importance of recruiting more top researchers to KTH to lift the overall research output intensity for KTH and co-publishing with other researchers outside KTH. However, as expected the publication cultures between different academic disciplines at KTH vary greatly, with some disciplines focusing on publishing books and others publishing primarily in refereed conference proceedings, while the majority publishes in peer reviewed journals, meaning that other criteria were found to be important to assess research excellence. Just as in the RAE of 2008, the many centres of excellence at KTH were identified by the expert panels as catalysts for creating strong and mutually beneficial relationships with academia and industry.

The KTH engagement with society, including industry, companies and other government agencies was found to be strong and vital, with a growing number of research centres and contracts with industrial partners over the period 2008-2011, as well as many co-published papers with industry and a growing number of industrial doctoral students and adjunct professors. KTH also continues to have a good innovation

performance with many successful patents and some fast-growing and highly profitable spin-off and start-up companies. The increased focus for supporting patenting and technology transfer, developed over the last four years, promises to lead to a sustainable and vital innovation footprint from the KTH research base. Finally, the wider impact on society from KTH research was found to be deep and highly relevant, as evidenced with 94 impact case studies, documenting the various impacts of KTH research on society. The results from the impact evaluation will lay the foundation for a strengthening of the KTH focus on describing its impact on society in the future.

The weaknesses identified by the expert panels were mostly associated with the need to invest in research infrastructure for ensuring sustainable research environments in the future, as well as to continue to strengthen the support for cross- and multi-disciplinary research, as well as strengthening several groups that were identified as having subcritical mass and impact through consolidation with other groups. The expert panels also identified the need to strengthen groups with a strong basic research component.

Following the recommendations of the expert panels, it will be proposed that the future research strategy of KTH will focus on the recruitment of top research talent, the continued strengthening of an inter- and cross-disciplinary research culture and an increased focus on the investment in research infrastructure and facilities for the future. Similarly, KTH will continue to enhance its collaboration and engagement with industry, companies and other agencies in Sweden and work to enhance the wider impact of its research on society. KTH will continue to strengthen its engagement with the European Institute of Innovation and Technology (EIT), which is Europe's preferred vehicle to enhance innovation and entrepreneurship in Europe through the integration of education, research and innovation. The main focus of future staff recruitment will be on young researchers who could proceed toward higher academic positions through the now established tenure track system, as well as on the recruitment of top international researchers to strategically strengthen the KTH research base. These changes will improve international visibility and strengthen the KTH brand, thus enabling KTH ambitions for true international leadership.

CHAPTER 1. INTRODUCTION

A research assessment exercise (RAE) was conducted at KTH for the first time in 2008. The inspiration came from similar exercises in the UK, Denmark and Norway. In addition, there was a connection to the government bill on research policy, which was put forward in 2008. The bill had been preceded by a white paper on Swedish research policy from 2007 where the focal argument was the need to boost the quality of Swedish research output. The definition of research quality adopted in the 2008 exercise was influenced by that on-going discussion in the Swedish university system.

The goal was to perform an international peer-review evaluation of the entire research base[1], which involved some 80 international experts from academia and industry. At that time, the KTH research base was split into 46 groupings (known as units of assessment, UoAs) and evaluated against five criteria; basic research quality, applied research quality, scholarship, vitality and potential, and research strategy. Independently, KTH commissioned a bibliometric study on KTH peer reviewed publications from 2000 to 2006.

The impact of RAE2008 is somewhat greater in retrospect than realized in the immediate aftermath of the exercise. This chapter reflects on the main lessons learned from research assessment in a four-year perspective.

Summary of lessons learned from RAE2008

Main conclusions from the peer review

The 2008 evaluation showed that KTH has a strong footprint as a technical research university and is able to take research findings forward into society. According to the international experts, over half of the KTH research units excel in both basic and applied research. Also, KTH has considerable research depth. Almost two-thirds of KTH research groups produce basic research at the international top level. The citation impact of KTH publications is significantly above international reference levels.

KTH is a successful innovation partner within Swedish society. Per unit of research expenditure, KTH now produces spin-offs at a rate comparable with MIT, Stanford and Cambridge and patenting levels match those seen at other top European universities. Two-thirds of KTH research groups produce applied research at the international top level.

1) The term research base is used for the purposes of RAE2012 to describe the complete collection and range of research areas that exist within KTH.

According to the recommendations of the experts in RAE2008, the future research strategy of KTH should focus resources on those areas that produce research at the highest international levels and consolidate research efforts in key areas of strength such as materials sciences, energy and environmental technology, information and communication technologies, transport, and technology for medicine and health.

The recommendations from the experts also included a reform of the internal research resource allocation system to support academic excellence as well as the societal relevance and business outreach, to focus future staff recruitments on young researchers who can proceed towards higher academic positions through a clear career track supported by stable basic funding, and to improve the international visibility of KTH and strengthen the KTH brand through communicating its research strengths.

Next steps

From the recommendations emanating from RAE2008, KTH composed a strategy for focusing on quality in its research processes, research management and research outputs. A first direct result in the area of research process was the strengthening of the role of university-wide leadership in research strategy through the establishment of the position of a vice president for research as well as the creation of a research office. That office had an important role to play in the creation of research platforms in line with the expert recommendations. The additional resources to leading universities for strategic research areas (SRAs), a major element in the 2008 government research policy, could also be allocated in a coordinated way with the help of the new internal support structures.

A direct result in research management was the handing out of research excellence bonuses within the internal research funding allocation system and the strengthening of the dialogue regarding research management between the KTH president and schools. At the other end of the research performance scale strategic investigations were started for those research groupings where the peer review had pointed out emerging declines in research output and research quality. Some ten such investigations have been performed during the period 2008-2012.

A direct result of the exercise in the research output field was the realization that quality work needed to be more systematic so that KTH could monitor its research performance in a more resource-effective way. These novel management structures to promote quality, also with regard to the measurement of outputs, for instance, to provide background materials concerning publications in international ranking schemes, have been maintained throughout the four-year period 2008-2012.

A first academic priority area was for KTH to focus on recruiting and developing excellent staff. RAE2008 identified a need to provide better career paths and support for young faculty. Tenure track positions are being opened for up-coming faculty, and a mentoring system has been developed to support their growth into strategic roles in their chosen research areas. KTH also continues actively to support the development of

female faculty and to add further international dimensions to its recruitment processes. Considerable progress has been made in the future faculty area in recent years.

A second academic priority area was for KTH to focus its resources on research of the highest international quality. RAE2008 showed that the skilful combination of basic and applied research can be said to characterize the top research environments at KTH, leading to vital technical research of high quality and societal impact. Further internal resources are now being allocated to support continued excellence in long-term strategic research at the best research environments at KTH. This area has been dynamic during recent years partly since KTH was successful in bringing in additional government resources into most of the fields of strength defined in RAE2008.

A third academic priority area was for KTH to focus on consolidating its research base and building high quality relations with partners in society. Key areas of research strength at KTH such as energy technologies, new materials, information and communication technologies, technology for medicine and health as well as transport systems have been supported in working together to deepen interdisciplinary insights and gain critical mass. Bridges have been built from basic research towards applications by creating strong interdisciplinary networks within the university and with other universities, research institutes and industries. This recommendation has given rise to a set of new initiatives relating to internal collaboration and to external networking.

A fourth academic priority was for KTH to focus on ensuring it has the necessary high quality equipment, infrastructure and support staff to deliver advances in research. Engineering research typically relies on experiments supported by complex research equipment and infrastructure including laboratory space and skilled technicians. A strong strategy is being put in place to ensure that engineers educated at and performing their research within KTH acquire, maintain and further develop their experimental competence. This area has increased in importance over the last few years. The recommendations in RAE2008 have made it possible to gain a good position in the currently on-going discussion about the role of research infrastructures for excellence in research.

A final recommendation from 2008 was for KTH to improve the communication of its research strengths to wider audiences. In the face of increasing international competition, KTH is working to strengthen its brand, especially internationally. The high number and citation rate of papers published suggest that KTH is visible within academic circles. The university has also taken a more active approach to communicating its work outside of these circles. The recent advances for KTH in several international rankings can be seen as an indication that the stronger focus on research communication has turned out to be more fruitful than anticipated.

A general conclusion from the summary of activities undertaken as a direct or indirect result of RAE2008 is that the investment in research assessment has paid off. The main effect is perhaps that RAE2008 created a new focus stressing that it is indeed important for KTH to monitor its research performance and to introduce mechanisms

to promote internal coordination of both research management and strategy. The most important recommendation seems to have been the one to renew faculty as a strategy for long-term excellence in research.

Overview of the RAE2012 process

RAE2012 aims

A technical university should contribute to knowledge and education as well as to society by fostering excellent basic and applied research in a host of fields, and by building relationships between these approaches and fields. A technical research university has a particular responsibility to transfer its research findings to, and interact with, industry and society when executing its strategy. This cannot be taken for granted and, at every strategic decision point, the route that leads to the highest possible level of quality must be chosen. The aims of RAE2008 were to identify excellence and leadership within the research base that could be strengthened, as well as opportunities for improvement in order to strengthen the international competitiveness of KTH.

RAE2012 continues the focus set by the 2008 exercise on producing and publishing a quality assessment that is comprehensible, produced by a transparent process, benchmarked against international standards through international expert peer review and use of bibliometry in order to identify the very best research at KTH.

The key aims of RAE2012 are to drive up quality across the KTH research base and to identify to what extent the KTH strengths are growing towards our common vision for being a leading European technical university and how previously identified weaknesses have improved. Further aims are to:

- Support and encourage all research, including basic curiosity-driven research and innovative applied research, new fields and interdisciplinary work
- Reward and encourage the effective sharing, dissemination and application of research findings and the productive interchange of research staff and ideas between KTH, business, and other public organizations
- Encourage UoAs that impact society through delivering benefits to business, the economy and society by building on excellent research
- Support better management and sustainability of the research base
- Provide a valuable input for the next four-year (2013-2016) development plan for KTH

Planning and organization of RAE2012

The RAE2012 process is headed by the KTH Vice President for Research. The Vice President is supported by an RAE2012 Director. Another support mechanism for the Vice President is via an internal planning group (IPG). The IPG, which is chaired by the Vice President, comprises the RAE2012 Director, senior academic and administrative managers from within KTH including the Dean of Faculty, plus representatives from the KTH faculty council (*fakultetsråd*). Some key persons from the 2008 exercise were also invited into the group. The IPG members were:

Björn Birgisson	Professor and Vice President for Research
Peta Sjölander	Lecturer and RAE2012 Director
Åsa Ankarcrona	Head of KTH Corporate Communications
Tim Anstey	Associate Professor and Director of Research for School of Architecture
Margareta Norell Bergendahl	Professor and Vice President, Faculty for Innovative Engineering
Anita Elksne	RAE2012 Assistant Director, Hospitality
Mats Engwall	Professor and member of KTH Faculty Council
Lisa Ericsson	Head of KTH Innovation
Thomas Eriksson	RAE2012 Senior Advisor, Evaluations
Göran Finnveden	Professor and Vice President for Sustainable Development
Oscar Andersson Forsman	Student representative
Sophia Hober	Professor and Dean of Faculty
Arne Johansson	Professor and member of KTH University Board
Sara Karlsson	KTH Quality Assurance Officer
Peter Kjellberg	RAE2012 Assistant Director, Communications
Nicole Kringos	Associate Professor
Ulf Kronman	KTH Library, Bibliometrics
Emma Källblad	External advisor, former Director of RAE2008
Susanna Pehrson	RAE2012 Assistant Director, Logistics
Göran Reitberger	RAE2012 Senior Advisor, Business Liaison
Sandra di Rocco	Professor and member of KTH Faculty Council
Peter Sjögårde	KTH Library, Bibliometrics
Folke Snickars	Professor and former Dean of Faculty

The management structure in a wider perspective is presented in Figure 1.

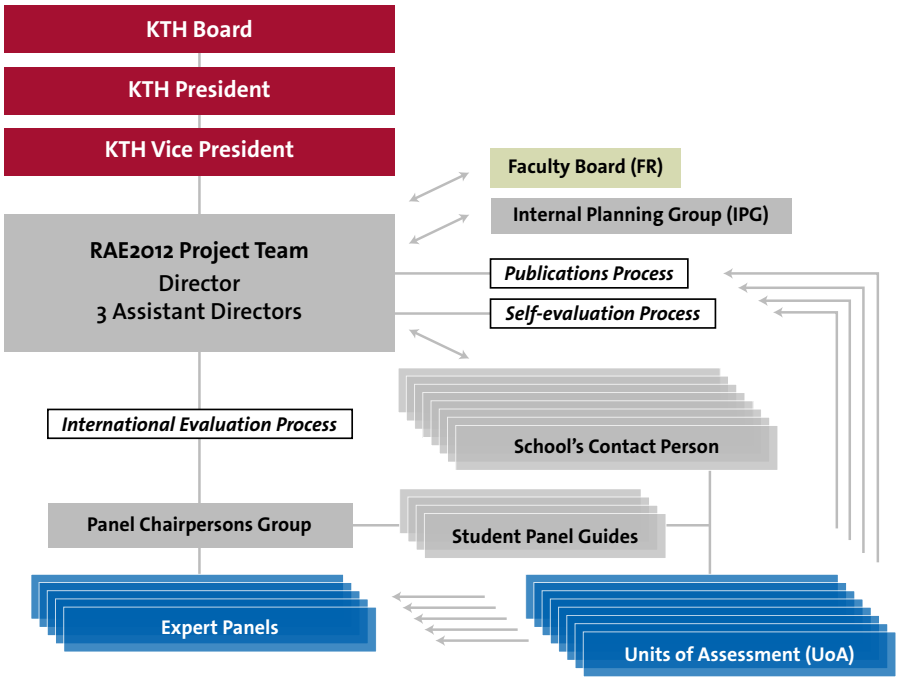


Figure 1: Overview of the RAE2012 management and process structure.

Defining the units of assessment

Units of assessment (UoAs) are deemed to be a collection of divisions or research groups, where a common goal and strategic plan is, or could be, established. Collectively a common vision of excellence in research outputs and environment, impact and social benefit in unison should be strived for.

There are 47 UoAs for the purposes of this evaluation process (see Appendix B). These 47 UoAs are in turn grouped into research fields (RFs) of which there are 13 in RAE2012. To a large extent, the UoAs and the RFs have not changed since the previous RAE, although some UoAs now belong to a different RF, and one new RF has been created since 2008.

In coordination with the relevant head of school (dean), each UoA elects a coordinator (UAC). The research field coordinators (RFCs) are appointed using a similar process and approved by the deans of the schools represented in the RF, as well as by the Vice President for Research. The RFC has overall responsibility for planning the site visit of the experts and are a point of contact with the RAE2012 management team. The UAC is responsible for submitting the evaluation package for the UoA.

The KTH research base was organized into 13 research fields and 47 UoAs, as follows:

RF1 Mathematics

Research field coordinator: Professor Anders Forsgren

1.1 Mathematics
1.2 Mathematical Statistics
1.3 Optimization & Systems Theory
1.4 Numerical Analysis

Panel chairperson: Professor Marta Sanz-Solé

RF2 Information & Communication Systems

Research field coordinator: Professor Carl-Gustaf Jansson

2.1 Information Processing, Networking & Control
2.2 Communication: Services & Infrastructures

Panel chairperson: Professor Anthony Ephremides

RF3 Physics & Theoretical Physics

Research field coordinator: Professor Olof Edholm

3.1 Experimental Physics
3.2 Theoretical Physics

Panel chairperson: Professor Eric Jakobsson

RF4 Applied Physics & Medical Technology

Research field coordinator: Professor Hans Hertz

4.1 Applied Physics & Medical Imaging
4.2 Medical Technology
4.3 Materials Physics
4.4 Optics & Photonics

Panel chairperson: Professor Wolfgang Eberhardt

RF5 Energy Technology & Electrical Engineering

Research field coordinator: Professor Hans-Peter Nee

5.1 Nuclear Power Safety, Reactor Physics & Reactor Technology
5.2 Electrical Power Engineering
5.3 Fusion & Space Plasma Physics
5.4 Energy Transformation

Panel chairperson: Professor Tuija Pulkkinen

RF6 Electronics & Photonics

Research field coordinator: Professor Mikael Östling

6.1 Microsystems Technology (MEMS)
6.2 Integrated Devices & Circuits
6.3 Embedded Electronics & Computer Systems

Panel chairperson: Professor Gehan Amaratunga

RF7 Applied Mechanics

Research field coordinator: Professor Dan Henningson

7.1 Vehicle Engineering
7.2 Solid Mechanics
7.3 Fluid Mechanics
7.4 Mechanics-Biomechanics

Panel chairperson: Professor Patrick Huerre

RF8 **Industrial Technology & Management**

Research field coordinator: Professor Jan Wikander

8.1 Industrial Product Development
8.2 Production Engineering
8.3 Health (Ergonomics; Health & Building)
8.4 Industrial Economics & Management

Panel chairperson: Professor Steve Evans

RF9 **Chemistry & Materials Science**

Research field coordinator: Professor Mikael Lindström

9.1 Chemistry
9.2 Chemical Engineering
9.3 Fibre and Polymer Technology
9.4 Theoretical Chemistry
9.5 Materials Science & Engineering

Panel chairperson: Professor Erik W. Thulstrup

RF10 **Biotechnology**

Research field coordinator: Professor Stefan Ståhl

10.1 Medical Biotechnology
10.2 Industrial Biotechnology
10.3 Proteomics
10.4 Materials Biotechnology

Panel chairperson: Professor Bertil Andersson, Vice Chair: Professor Hanno Langen

RF11 **Technology for the Built Environment**

Research field coordinator: Professor Lars-Göran Mattsson

11.1 Civil & Architectural Engineering
11.2 Land & Water Resources
11.3 Transport Science

Panel chairperson: Professor Cynthia Barnhart

RF12 **Architecture & the Built Environment**

Research field coordinator: Associate Professor Helena Mattsson

12.1 Architecture
12.2 Real Estate & Construction Management
12.3 Philosophy & History of Technology
12.4 Urban Planning & the Built Environment
12.5 Industrial Ecology

Panel chairperson: Professor Rachelle Alterman

RF13 **Computer Science & Mediated Communications**

Research field coordinator: Professor Anders Askenfelt

13.1 Theoretical Computer Science
13.2 Applied Computer Science
13.3 Mediated Communications

Panel chairperson: Mary Czerwinski, Vice Chair: Professor Dieter Gollmann

International expert panels

For each of the 13 research fields, a panel of experts was recruited. These experts were drawn from the international academic society and consisted of high-level scientists with many years of experience in their field of expertise. Each panel was headed by a chairperson, and these chairpersons were selected first. Expert chairpersons and panelists are approved by the KTH Vice President for Research. The criteria for selection of the chairperson include the requirement of a broad background in the research field in question, being a distinguished scientist and/or industrialist with high integrity, having experience with international evaluations, being suitable for assuming chair responsibilities and being not active in Sweden. The experts should have either an academic or relevant industrial background in any one research field. Experts must be impartial with no economical, research-associated or other significant links with the groups they will assess in particular or KTH in general, since January 2007. All UoA major research areas within the research field in question must be represented within the panel. The resulting number of panelists per research field were:

PANEL NUMBER AND NAME	NO. UoAs	NO. PANELISTS
1: Mathematics	4	8
2: Information & Communication Systems	2	7
3: Physics & Theoretical Physics	2	6
4: Applied Physics & Medical Technology	4	7
5: Energy Technology & Electrical Engineering	4	8
6: Electronics & Photonics	3	6
7: Applied Mechanics	4	8
8: Industrial Technology & Management	4	9
9: Chemistry & Materials Science	5	10
10: Biotechnology	4	8
11: Technology for the Built Environment	3	7
12: Architecture & the Built Environment	5	11
13: Computer Science & Mediated Communications	3	6
TOTAL	**47**	**101**

The three parts of the evaluation

RAE2012 activities were split into three parts (see Figure 2).

PART 1: PUBLICATIONS DATA FROM INDIVIDUAL SCIENTISTS

Publication data (including peer-reviewed journal publications, peer-reviewed conference papers, books, chapters and registered patents) were gathered and stored in the KTH publications database, DiVA[2]. Normalization of these data by field of study was undertaken for each unit of assessment.

PART 2: AN EVALUATION PACKAGE BASED ON UoA GROUP DATA

UoAs completed a self-evaluation questionnaire in two parts, including facts and figures, major research activities and outcomes, strategy, actions for renewal and research infrastructure. Together these data were gathered into an evaluation package (see Appendix A). Individual CVs were also collected online during this period.

PART 3: INTERNATIONAL EXPERT EVALUATION

Panels of invited international experts received the above-mentioned evaluation packages, plus the bibliometric reports, several weeks before their arrival in Stockholm. The expert panels spent one week, June 11-15, in Stockholm visiting the UoAs and provided instant feedback to the KTH leadership on the final day of the visit.

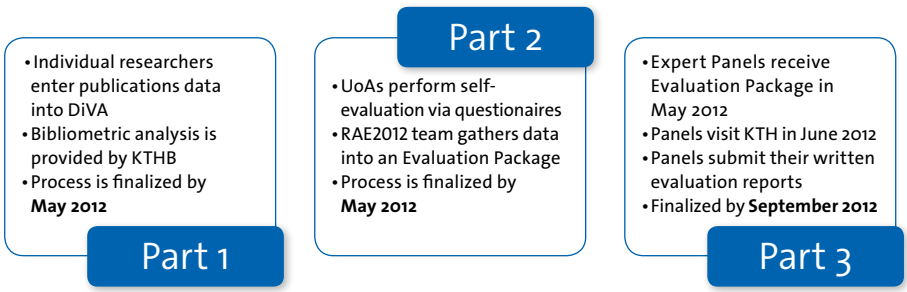


Figure 2: Overview of RAE2012 procedure and deadlines.

2) The DiVA portal is a finding tool for research publications and student theses written at one of thirty universities and colleges of higher education in Sweden (www.diva-portal.org).

Categories for evaluation in RAE2012

One conclusion from the RAE2008 experience was that the definition of research excellence and the linked choice of assessment dimensions needed further development. Excellence in research means that the quality of the research is recognized by international peers in terms of originality, significance and rigour. This is the academic footprint dimension of KTH research. But excellence in research also means that the research is recognized by the international peers as having an impact on societal and economic development. This is the societal and economic footprint dimension of KTH research.

In the current international and national discussion about excellence in research the need to address the research impacts is being strongly put forward. This does not mean that the importance of excellence in basic research is played down. It rather means that it is important to broaden and make more systematic the values produced by university research in its context of education and industrial and societal outreach.

The three broader categories of research output quality, impact and engagement with society, and research environment were therefore chosen as basic dimensions of evaluation in RAE2012.

Quality of research output evaluation criteria

The excellence of scientific output is the essential prerequisite to high quality in knowledge creation and innovation. Considering the complexity of today and tomorrow's society, scientific research will need to contribute via multidisciplinary innovative solutions. As such, the development efforts, the wider outlook towards society's problem and the ability to develop multidisciplinary methods, with which to solve those problems, should be evaluated as well. The purpose is to assess the quality of original research, which is done in terms of originality, significance and rigour, with reference to international research quality standards.

Originality is understood as the extent to which the output introduces a new way of thinking about a subject, or is distinctive or transformative compared to previous work. Significance implies the influence on an academic field or practical application, while rigour defines to what extent the purpose of the work is clearly articulated, the methodology is appropriate and compelling evidence shown that the purpose has been achieved.

All forms of research output were considered equitably in terms of the assessment, with no distinction being made between the types of output submitted, nor whether the output was made available electronically or in a physical form. All forms of output were welcomed. Examples of typical research outputs include published papers, books, book chapters, conference contributions, new materials and devices, patents, software, standards, physical and digital artefacts, and research-based clinical case studies, and evidence synthesis.

When evaluating, the panels used the following criteria to assess the quality of the research output:

Criteria

- Quality that is world-leading for the majority of the UoA
- Quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA
- Quality that is recognized internationally for the majority of the UoA
- Quality that is recognized nationally for the majority of the UoA
- Quality that falls below the standard of nationally recognized work for the majority of the UoA

Impact and engagement with society evaluation criteria

For the purposes of RAE2012, 'impact and engagement with society' is defined as an effect on, change, or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia. In its role as a knowledge provider, driving social and economic growth, KTH wishes to further extend and develop its reach and significance in society.

The submission requirements for impact include the impact statement, in which the UoA's strategy for impact is described, and two impact case studies. These formed the basis upon which the expert panels assessed the unit's impact. The submission requirements for engagement with society included information on three distinct categories of activity: mobility between academia and industry, collaboration in research, and dissemination of research.

The first category included ways to foster or strengthen strategic partnerships and includes numbers of industry doctoral students, researchers with a temporary position at an external organization, adjunct professors and number of doctoral theses resulting from collaboration with external organizations as well as publications co-authored with non-academic parties.

Collaboration in research included the number of visits to external organizations, research projects collaborating with external organizations and invited guest lecturers from external organizations. Dissemination of research included the number of popular science publications, lectures to the public, and other reach-out activities to the general public such as open house events, participation in science cafés and festivals and in TV/radio.

The criteria for assessing impacts are 'reach' and 'significance'. When assessing impact and engagement with society, the panels were asked to form an overall view about the 'reach and significance' taken as a whole for the majority of the UoA, rather than to assess 'reach and significance' separately. For the impact statement and associated

case studies, the panel considered the extent to which the UoA's approach described in the template was conducive to achieving impacts of 'reach and significance'. When evaluating impact and engagement with society, the panels used the following criteria:

Criteria

- Outstanding impact and engagement with society for the majority of the UoA
- Considerable impact and engagement with society for the majority of the UoA
- The impact and engagement with society is marginal to non-existent for the majority of the UoA

Research environment

To produce excellent research a group or department must thrive and renew itself. The composition of the unit of assessment with regard to its academic staff, research students and other staff, strategic planning, the quality of links between research and graduate education and the research infrastructure available are all essential in achieving a good research environment. Hence, the quality of the research environment was assessed based on the unit's vitality and sustainability, defined as follows:

- Vitality – the extent to which the UoA provides an encouraging environment for research, has an effective strategy, is engaged with the national and international research and user communities, and is able to attract excellent doctoral and postdoctoral researchers
- Sustainability – consideration of leadership, vision for the future and investment in people, graduate education and infrastructure and, where appropriate for the subject area, the extent to which activity is supported by a portfolio of research funding.

Taking into consideration 'vitality and sustainability', the panels were asked to use the following assessment criteria:

Criteria

- An environment that is conducive to producing research of world-leading quality for the majority of the UoA.
- An environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.
- An environment that is not conducive to producing research of nationally recognized quality, in terms of vitality and sustainability for the majority of the UoA.

Bibliometric analysis

To complement and supply background information to the expert peer review process in RAE2012, KTH conducted a bibliometric study of the research output and impact of its researchers. It should be emphasized that the bibliometric study was not used as a primary tool for evaluation in RAE2012. Rather, it was a complement to the self-assessment package and the site visits by the expert panels. The bibliometric study focuses on the analysis of the publication records derived from each UoA and provides an international field normalized framework for comparing the impact of these publications.

The bibliometric study was a prospective study, which means that all researchers employed at KTH on the census date of December 31, 2011 were included. The time-frame for the bibliometric study included the years 2004-2011. All publications by those researchers meeting the above inclusion criteria were included in the study, whether produced at KTH or elsewhere. The analysis was subsequently performed at the individual researcher level and then aggregated to the unit of assessment level.

The primary data source for the bibliometric study was the KTH publication database, DiVA. Publication counts and their distribution over different document types for the years 2004-2011 were retrieved directly from the DiVA database. All document types as well as patents were included in the publication counts.

For citation counts and indicators on internationalization, subjects and journals, DiVA records were matched against records from Thomson Reuters' Web of Science (WoS), using the WoS unique record identifiers stored in DiVA. For field and journal normalized indicators, the WoS unique identifiers were sent to the Karolinska Institutet bibliometric system for analysis. Citation counts were based on publications from the years 2004-2010[3].

The bibliometric indicators were chosen so as to provide a multi-faceted picture of publication activity and publication culture. Publication productivity and impact measured by various indicators of citation rates, as well as co-publication patterns were described. Both absolute indicators and relative indicators were presented to the expert panels, including normalized indicators.

The bibliometric indicators should not be considered in isolation but rather in relation to other indicators as well as in relation to the peer review and self-evaluation. By supplying the bibliometric study to both the panel members and the units of assessment, the bibliometric study constitutes an integrated and complementary part of RAE2012.

3) Due to the delayed nature of citations, the year 2011 was not included in the citation analysis.

KTH in brief

KTH in Stockholm is the largest, oldest and most international technical university in Sweden. No less than one-third of Sweden's technical research and engineering education capacity at university level is provided by KTH. Education and research spans from the natural sciences to all branches of engineering and includes architecture, industrial management and urban planning. The educational programmes lead to bachelor, master or doctoral degrees in engineering, science or architecture. There are a total of almost 14,000 undergraduate students and more than 1,700 active postgraduate students at KTH. KTH has just over 4,600 employees in total. Some numbers are provided here for comparison between 2011 and four years ago during the last evaluation:

	2008	2011
MSc engineering programmes	15	16
Architecture programmes	1	1
Masters programmes	53	64
No. enrolled undergraduate students	12,230 (29% W)	13,296 (30% W)
No. active research students (≥50 % activity)	1,507 (29% W)	1,732 (29% W)
PhDs granted	235 (29% W)	235 (26% W)
Professors[4] (FTE)	272 (10% W)	295 (11% W)
Associate professors (FTE)	194 (14% W)	228 (21 % W)
Assistant associate professors (FTE)	35 (31% W)	74 (23% W)
Total staff members (FTE)	2,833	3,375
Total refereed publications in the year	1,830	2,000
Total turnover[5] (MSEK)	3,151	3,941
Total revenue for research and graduate education (MSEK)	2,054	2,501

(W = women), source: KTH annual reports, 2008 and 2011

4) Including visiting professors and adjunct professors.

5) Including transfers.

Research at KTH

KTH research base falls into 13 research fields:

1 Mathematics

2 Information & Communication Systems

3 Physics & Theoretical Physics

4 Applied Physics & Medical Technology

5 Energy Technology & Electrical Engineering

6 Electronics & Photonics

7 Applied Mechanics

8 Industrial Technology & Management

9 Chemistry & Materials Science

10 Biotechnology

11 Technology for the Built Environment

12 Architecture & the Built Environment

13 Computer Science & Mediated Communications

KTH academic activities are conducted within ten schools. Each school contains a number of departments and centres. As the School of Education and Communication in Engineering Science (ECE) was established in January 2011, it has not been evaluated as part of RAE2012. The nine schools thus evaluated are:

- School of Architecture & the Built Environment (ABE)
- School of Biotechnology (BIO)
- School of Chemical Science & Engineering (CHE)
- School of Computer Science & Communication (CSC)
- School of Electrical Engineering (EES)
- School of Information & Communication Technology (ICT)
- School of Industrial Engineering & Management (ITM)
- School of Engineering Sciences (SCI)
- School of Technology & Health (STH)

Figure 3 shows the development of total income for the four year period, 2008-2011. Income has increased from 3,151 MSEK to 3,713 MSEK during this period, i.e. an increase of about 18 percent. Interestingly, both governmental funding and external research funding have increased in approximately equal proportion; an increase of approximately 290 MSEK for each category.

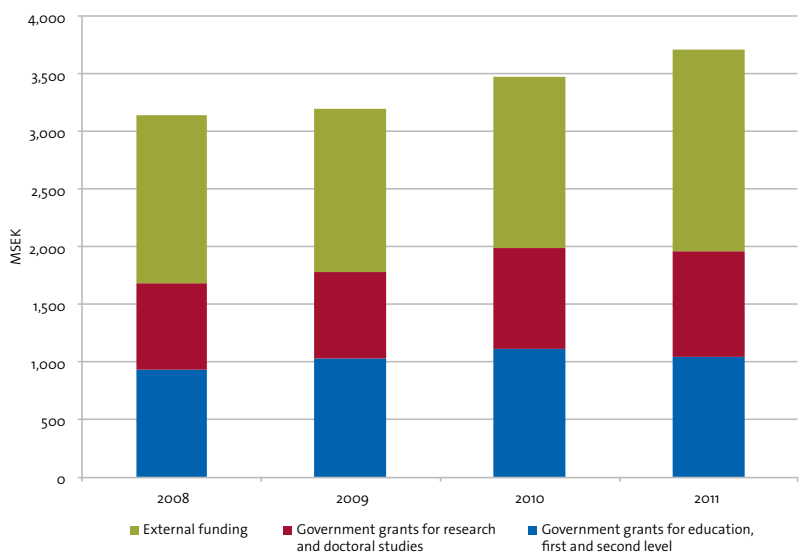


Figure 3: Sources of income for KTH, 2008-2011. *Source: KTH annual reports 2008-2011.*

Government funding

Over the period 2008-2011, overall government funding to KTH for research and doctoral studies has grown from 739 MSEK to 917 MSEK, an increase of 19 percent, while total government grants for first level education has grown from 926 MSEK to 1,054 MSEK, reflecting a 12 percent increase[6].

Government grants for research and doctoral studies equalled 24.7 percent of total revenue in 2011, compared to 23.5 percent in 2008. Seen as an explanation for the overall growth of research and doctoral studies it only gives a partial understanding, since these grants have grown less than other sources of research revenue.

Grants from individual funding bodies and other financiers

A strong factor in explaining the growth of research revenues is the growth of grants from individual funding bodies, such as the EU, the Swedish Research Council (*Vetenskapsrådet*), Swedish government authorities and private foundations. These consisted of 926 MSEK in 2007 while, in 2011, grants from individual financiers grew to 1,390 MSEK, a 50 percent growth.

National and international outlook

In the autumn of 2008, the Swedish government designated 20 areas as being of strategic importance, i.e. the so-called strategic research areas (SRAs). These prioritized research areas received additional government funding, which was allocated through a competition among Swedish universities. KTH was awarded funding within 11 SRAs and leads activities in five of these areas namely ICT, molecular bioscience, transport, production and e-science. In addition, KTH is a key partner in the energy SRA, STANDUP, along with Uppsala University. In 2012, KTH received 144 MSEK in government funding for its part in the SRAs.

KTH is also part of two of the first ever EIT KICs (European Institute of Innovation and Technology[7] knowledge and innovation communities), one in energy and the other in ICT.

6) KTH annual reports, 2008 and 2011.

7) www.eit.europa.eu

KTH research platforms and centres

In 2009, KTH established five research platforms to facilitate the coordination of research activities across the university and to increase KTH preparedness for addressing complex inter- and multidisciplinary complex research funding calls. This was a direct response to the challenges related to fragmentation of research pointed out by RAE2008, as well as extensive research intelligence highlighting the increasing need of multidisciplinary research and stronger collaboration with society and industry. The platforms cover the areas of energy, materials, life science technology, information and communication technology, and transport.

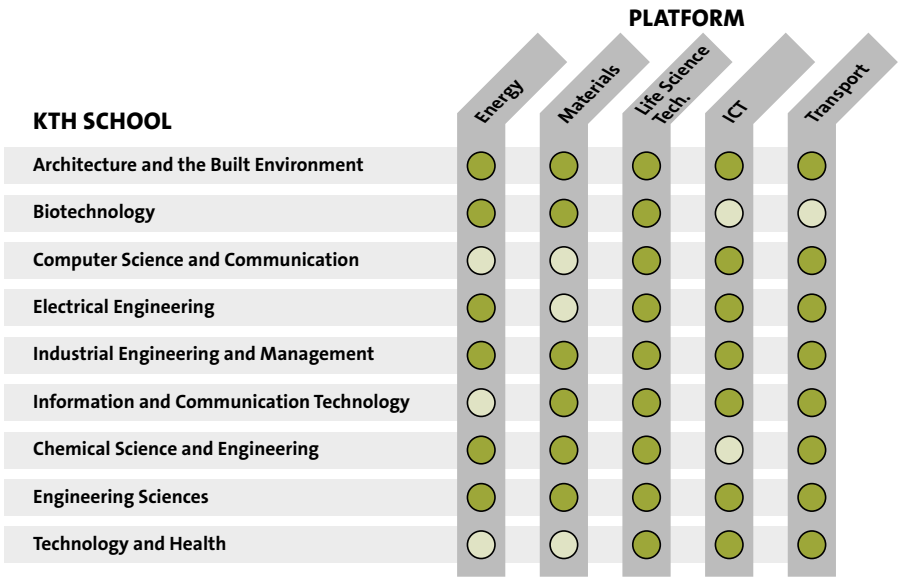


Figure 4: Mapping of KTH school research activities to KTH platforms: dark green circles represent schools with a critical mass of research in a given platform area.

There are more than 40 research centres at KTH. The majority are financed through long-term commitments from, for example, the Energy Agency, Mistra and Vinnova. Funding also comes from the participating industry partners, as well as in-house funding from KTH. Between them, the centres cover the major part of KTH research base.

CHAPTER 2. SUMMARY OF RESULTS AT THE KTH LEVEL

Almost half, 22 out of 47, units of assessment were assessed as being of quality that is world-leading for the majority of the UoA in regards of research output. 'World-leading' is defined as being a driving force in their field of research. A further 16 UoAs were assessed as having 'quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA'. More than half of the UoAs, i.e. 24 of 47 were assessed as having 'outstanding impact and engagement with society for the majority of the UoA'. In terms of research environment, 16 out of 47 units of assessment were assessed as having 'an environment that is conducive to producing research of world-leading quality for the majority of the UoA'. Overall, research environment was identified as the area needing most attention in the future. A few groups were identified as having subcritical mass and impact and thus consolidation with other groups was suggested by the panels.

General recommendations by the panels at the university level

The recommendations have been divided into the following subgroups; KTH organization, staff, funding, interdisciplinary work and initiatives at school level, and impact and engagement with society.

Recommendations relating to KTH organization

In order to have a clear vision, the work with formulating strategy plans on all levels in the organization needs to be emphasized according to many panels. Those panels recommended that UoAs formulate strategy plans, or focus on an already existing plan. Plans should include goals addressing, among other things, faculty development and succession planning, research direction, diversification of sources of support and identifying new promising areas or new trends. In addition, the area of sustainability, as a holistic approach, needs to be lifted to a higher level in order to get a shared understanding of the concept and formulate its aspirations.

Recommendations relating to KTH staffing issues

The comments relating to staff fall into two main categories, mobility and career management, whereof mobility was highlighted by many panels. The need of mechanisms for increased mobility is frequently mentioned, and suggestions include that new staff and doctoral students should be encouraged and promoted to spend time at research-competent top institutions, to get help to come in contact with these and to acquire financial support. Another suggestion was to recruit more international faculty in order to maintain intellectual diversity. Training of new doctoral students and new faculty should be delivered in an efficient way, which also incorporates support in career management.

Gender balance is an area where a continued effort is needed. The panels mentioned the importance of active work in achieving a more equal gender balance.

Several environments at KTH, identified as world-leading and unique in their respective area, are recommended to use their current position to attract the very best professors and associate professors to further strengthen their position in a long-term perspective.

Recommendations relating to KTH funding

Many panels comment on a need to maintain a better balance between base funding and external research income, which would also prevent gaps in short-time funding, both regarding support to the experimental work and for continuous technical and engineering support and rent. Some Panels argue that a higher base support would allow for an increased number of PhD students and would reduce the risk of excellent researchers being unable to maintain their careers at KTH.

Connecting to the funding are recommendations to aim at higher impact and higher risk research, which has the potential of yielding greater research rewards.

Also to be considered is the introduction of an incentive system to reward young academics who are successful in attracting substantial external funding, both as a possibility to attract more external funding and attract young researchers to KTH.

Another recommendation was for KTH to consider specific funding of joint projects.

Recommendations relating to KTH interdisciplinary work and initiatives at school level

Further incentives are needed to strengthen internal collaboration at KTH according to many panels, such as providing seed money for collaboration and asking school deans to identify strategic collaboration opportunities.

There were several suggestions connected to the KTH platforms. For example a basic science platform might be a useful complement to the existing platforms.

Recommendations relating to impact and engagement with society

To make basic research more visible, it is recommended that KTH researchers publish more often with external partners. KTH could also consider reappraising its processes for identifying research output worthy of commercialization and that patenting and innovation activities ought to be strengthened through education and networking with industry.

Analysis of the quantitative data

Income

TURNOVER FROM EDUCATION, EXTERNAL AND INTERNAL RESEARCH INCOME

Income is composed of three main parts: government grants for research and doctoral studies (*forskning och forskarutbildning*, FoFu); government grants for education, first and second level (*grundutbildning*, GRU); and income from external financiers (Ext). A comparison of FoFu, external research money and FoFu each year provides a useful description of the economic environment for the UoA. Figure 5 shows these three sources of income for the period 2008-2011, with UoAs ranked by the amount of research money spent (i.e. the sum of FoFu and Ext). The figure shows that the economy of some UoAs is dominated by GRU, while for other UoAs the contribution from education is relatively small.

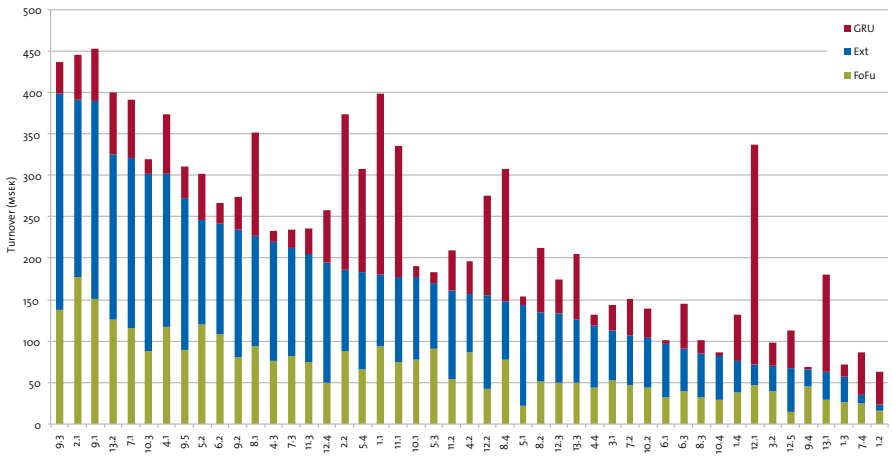


Figure 5: Total turnover for each UoA from government education funding (GRU, red), government external funding (Ext, blue) and research funding (FoFu, green) for the period 2008-2011 (ranked by FoFu+Ext).

A comparison of GRU, FoFu and Ext funding spent by a research field in any one year provides a useful overview of the economical environment for the whole RF. Figure 6 shows the same three sources of income, for the period 2008-2011, but aggregated for each RF.

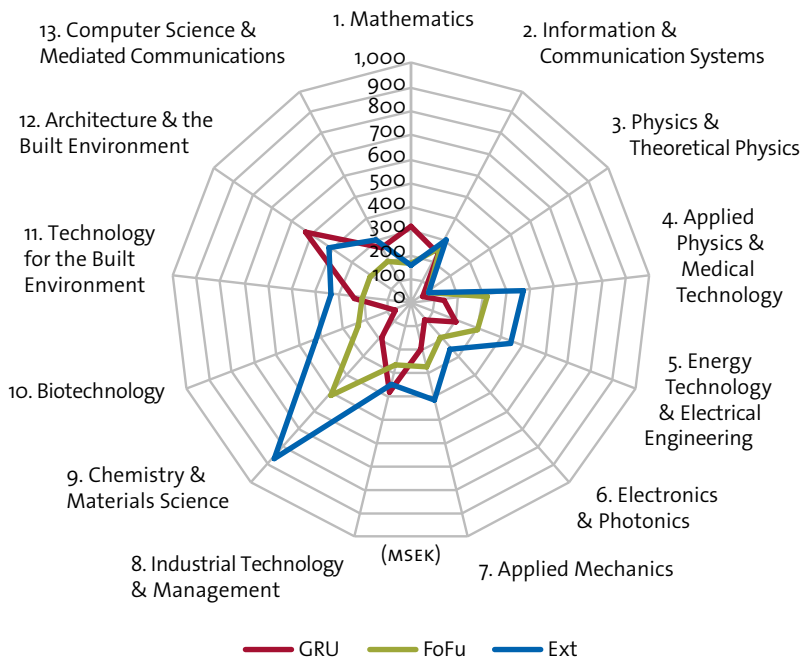


Figure 6: Turnover of government education funding (GRU, red), government research funding (FoFu, green) and external research funding (Ext, blue) at RF level for the period 2008-2011.

As Figure 6 demonstrates, external research turnover is generally greater than either FoFu or GRU turnover. Where education turnover (red) is the larger amount, this can be explained as the disciplines mathematics (RF1), Industrial Economics & Management (RF8), and architecture (RF12) are traditionally associated with greater levels of teaching at technical universities such as KTH.

EXTERNAL RESEARCH TURNOVER

For RAE2012, external research turnover was divided into the following sub-areas:

- **Research councils:** monitoring the turnover from the Swedish Research Council, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, and the Swedish Council for Working Life and Social Research[8]
- **Swedish Energy Agency and VINNOVA:** monitoring the turnover from these two agencies
- **Other public bodies:** monitoring turnover from other Swedish agencies (including the Swedish government, parliament, and ministries), county administrative boards, county councils, regions, and municipalities
- **Industry:** monitoring turnover from industry worldwide
- **Swedish foundations:** monitoring the turnover from Swedish foundations
- **EU:** monitoring the turnover from the EU research council, framework programmes and regional funds
- **Other international:** monitoring other international sources besides international industry and EU
- **Other:** monitoring those sources that is not covered above e.g. Swedish donations

Figure 7 presents the external research turnover for each research field (i.e. the blue line 'Ext' from Figure 6) separated into amounts for: a) Swedish public bodies; b) Swedish foundations; c) industry; and d) EU money.

8) The Swedish Research Council (Vetenskapsrådet, VR), the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas), the Swedish Council for Working Life and Social Research (FAS).

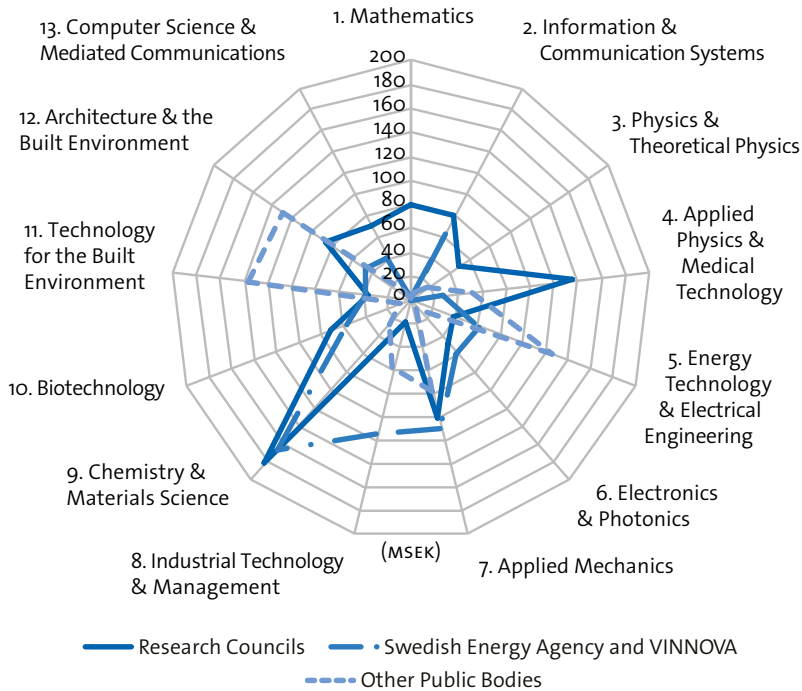


Figure 7a): Swedish public bodies.

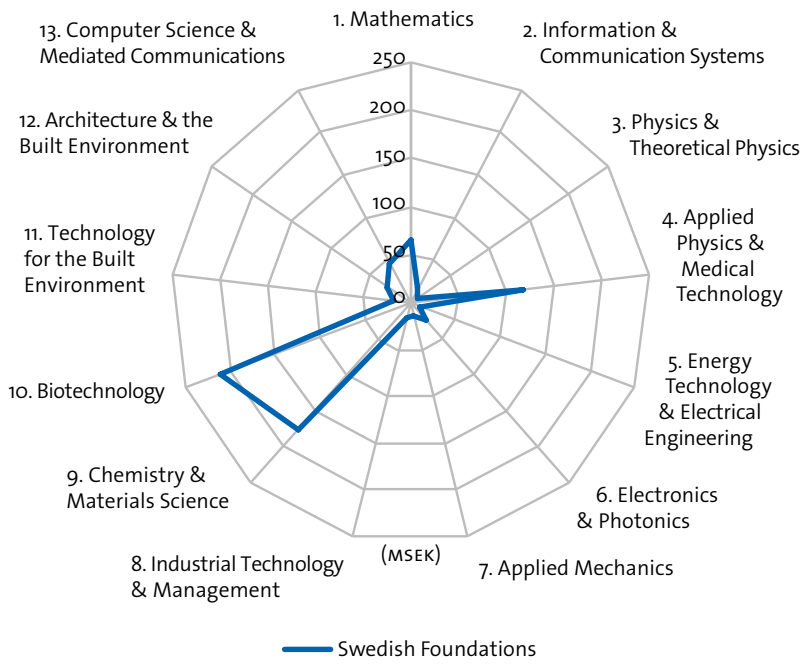


Figure 7b): Swedish foundations.

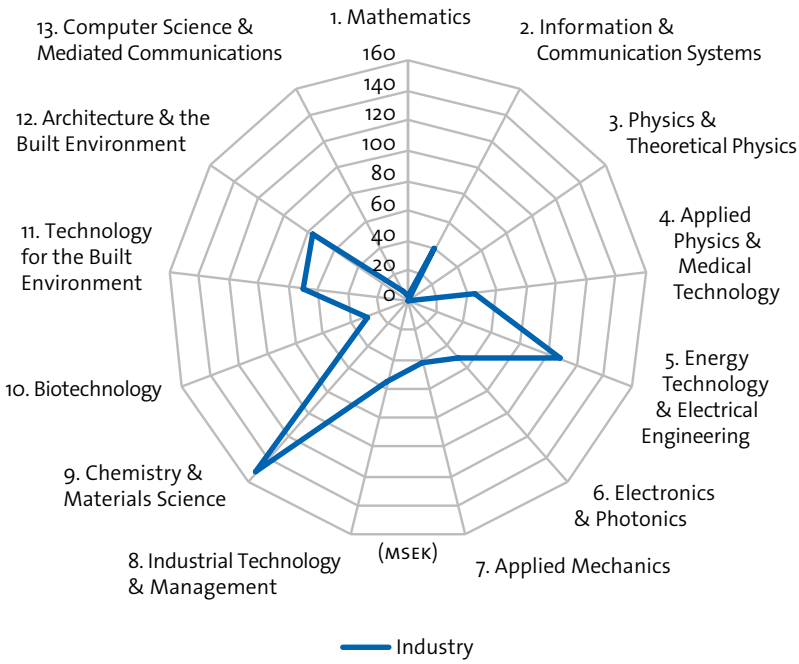


Figure 7c): Industry.

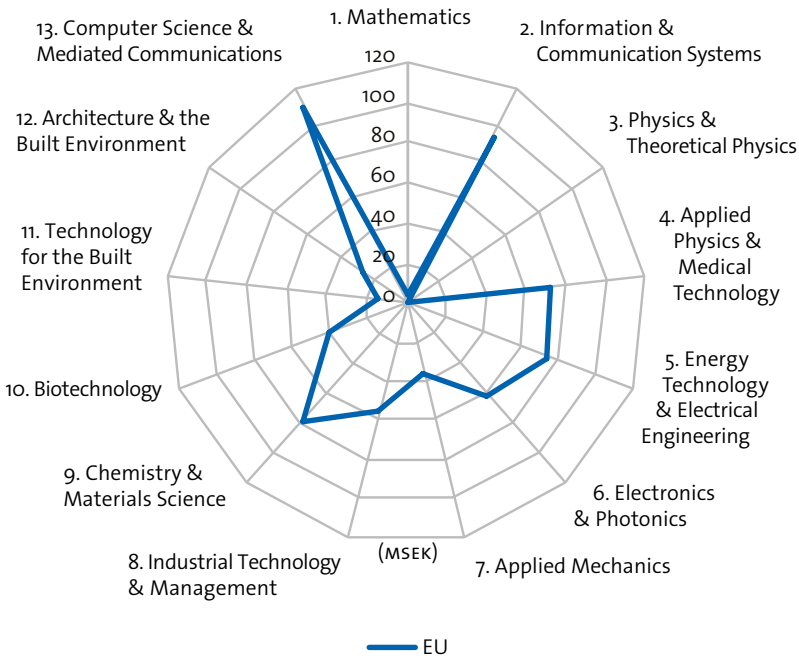


Figure 7d): EU funding.

Figure 8 shows the distribution of internal and external funding in 2011. Most research fields have a substantial share of external relative to internal funding. Chemistry & Materials Science (RF9) is the research field with the largest research resources amounting to an impressive 370 million SEK per year.

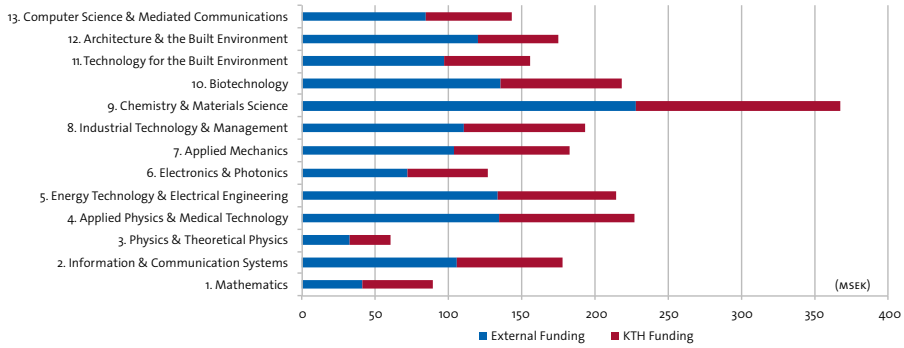


Figure 8: External and internal funding for research only (education funding not shown), across the 13 research fields (2011).

Patents

Figure 9 provides an overview of patents (worldwide) per research field between 2008 and 2011 and the number of companies founded in the same years. The distribution varies markedly across research fields. The distribution across research fields for intellectual property registered is different from the one for companies founded. The exception is the research field Applied Physics & Medical Technology (RF4) where both of the indicators show high values relative to the rest of KTH. The research field of Computer Science & Mediated Communications (RF13) stands out in view a small amount of intellectual property registered and a large number of companies founded.

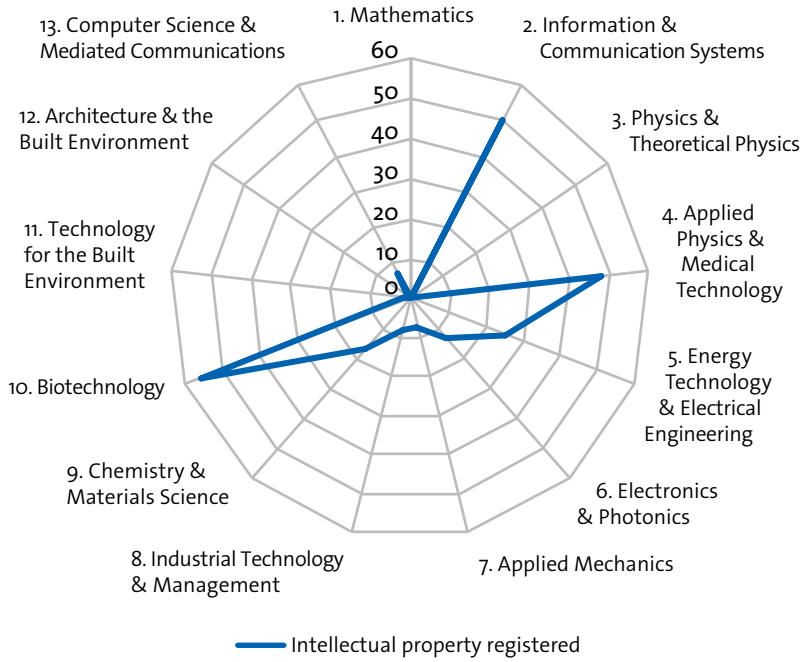


Figure 9a): Intellectual property.

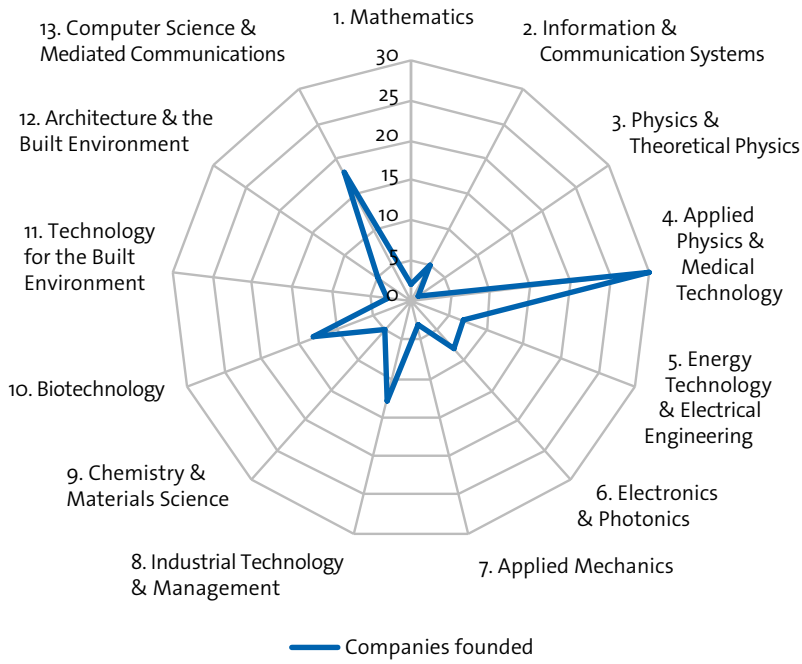


Figure 9b): Companies founded.

Staff

Overall, there was an increase in the number of academic staff within each category during the period of investigation, as Figure 10 demonstrates. The numbers cannot be compared directly with similar data published in 2008 due, at least in part, to changes in professional title over the last few years.

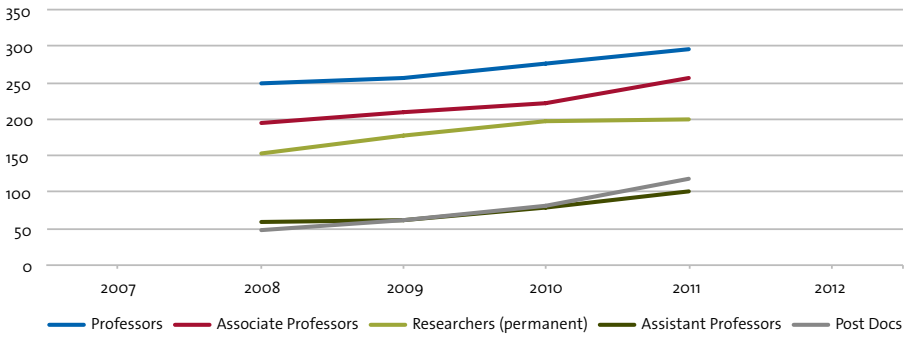


Figure 10: Increase in numbers of academic staff between 2008 and 2011.

Figure 11 shows the age distribution across KTH professors in 2011. The data is rather similar to those of 2008. In relative terms rejuvenation is particularly pronounced in Energy Technology & Electrical Engineering (RF5). Many professors above 60 years of age are found in Architecture & the Built Environment (RF12) and Chemistry & Materials Science (RF9).

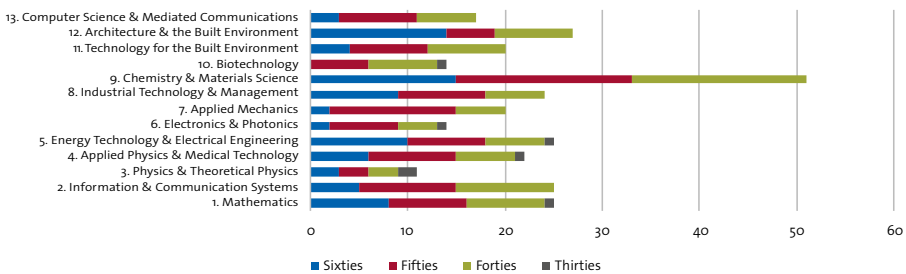


Figure 11: Age distribution of professors at KTH (2011).

Mobility

Figure 12 shows the numbers of incoming and outgoing senior researchers for 2008 - 2011. The indicators are not quite comparable since the outbound flow consists of all researchers and the inbound flow consists of a more limited number of academic categories. The striking part of the pattern is the concentration of flows through the system in the research fields of Industrial Technology & Management (RF8) and Chemistry & Materials Science (RF9). The flows are very small for some research fields indicating that mobility may take on other forms, such as short term visits to KTH (incoming) and conference participation (outgoing).

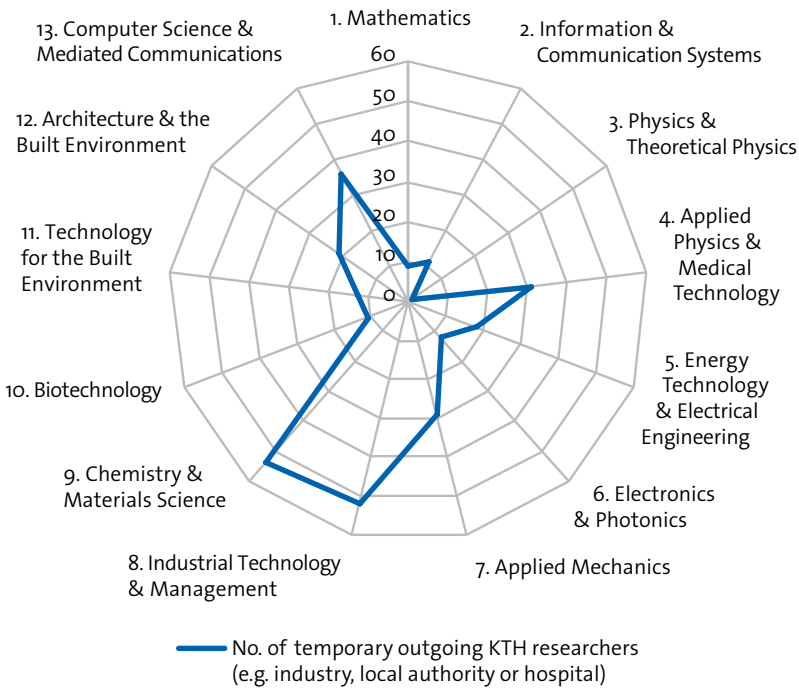


Figure 12a): Outbound mobility between academia and industry 2008-2011.

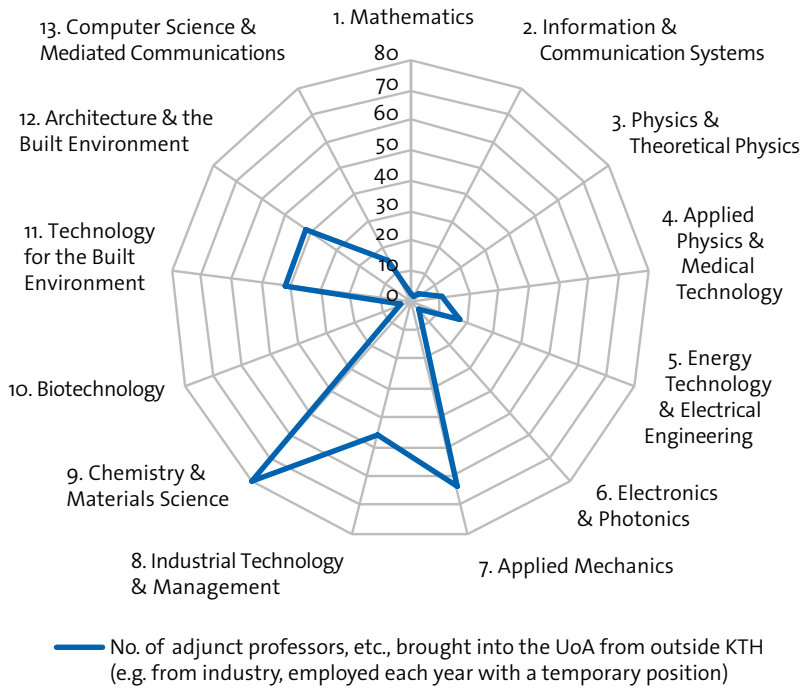


Figure 12b): inbound mobility between academia and industry 2008-2011.

An observation from the presentation of quantitative data from the UoAs and the associated research fields is that there is a considerable variety between different parts of KTH. Some of the explanation of these differences may be found in the fact that the impacts follow similar patterns for similar research fields in other universities. Seen in this perspective it will be important to relate the pattern for the research fields of, for instance, Mathematics (RF1), Biotechnology (RF10), or Technology for the Built Environment (RF11) to corresponding fields in other technical universities. This would correspond to the discussion of field normalization in the calculation of scientific impacts.

The conclusion is that variations in patterns of working with industry and society, mobility, patenting and company formation are substantial across KTH. There is thus a need for methodological developments involving several universities before field normalization criteria can be designed for economic and societal impacts.

CHAPTER 3. ECONOMIC AND SOCIETAL IMPACT OF KTH RESEARCH

With RAE2012, KTH became one of the first universities ever to concretely evaluate the economic and societal impact of the research performed. In this context, impact in RAE2012 is defined as an effect on, change, or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia. With the input from RAE2012 it will now be possible to describe the KTH role in society more completely, enhance the mapping of the impact, and target novel development areas in impact space better in the future.

Assessment of impact was undertaken by the expert panels within the evaluation category 'impact and engagement with society'. Each UoA was asked to explain their strategy to impact, the so-called impact statement, and were also given the possibility to provide a maximum of two examples of impact beyond academia originating from their UoA, in a case-study format. In total, 94 impact case studies were collected.

Since the guidelines on how to write the impact statement and the impact case studies were very open it was up to the UoA to present their approach to impact and what impact means for their UoA. The results are thus statements and cases written from the researcher point of view.

The impact statement and the impact case studies constituted an essential base for the expert panels in their assessment of the UoA 'impact and engagement with society'. Overall, this category received the most favourable evaluations. More than half of the UoAs were deemed to have an outstanding impact and engagement with society for the majority of the UoA. The remaining UoAs were assessed to have a considerable impact and engagement with society for the majority of the UoA. Careful analysis shows that the assessment of the 'impact' category is closely connected to the 'research output' category in that a positive review concerning one is frequently associated to a positive review of the other.

Besides the assessment of the impact by the expert panels, KTH has initiated a study characterizing the overall KTH impact and engagement with society based on the case studies from RAE2012. The results of that study will be published in a companion report to the current one.

Impact indicators at KTH

Besides the assessment of the impact by the expert panels, KTH has initiated an on-going project aiming to characterize the overall KTH impact and engagement with society based on the input from RAE2012. An initial part of that work has been to find suitable categories of impact. A role model for such work is the categories proposed by the Research Councils UK (RCUK) covering academic impacts as well as economic and societal impacts, see Figure 13.

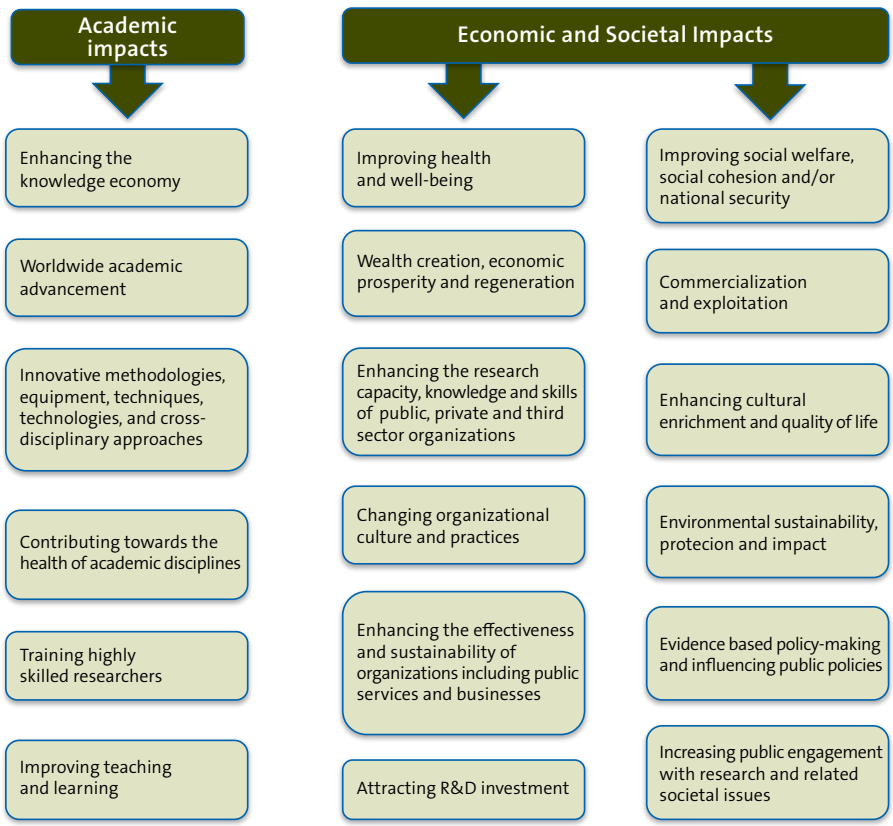


Figure 13: 'Pathways to impact', as proposed by the four UK higher education funding bodies[9].

9) 'Pathways to impact': http://www.rcuk.ac.uk/documents/impacts/RCUKPathwayspresentation.pdf

This model has served as a stepping stone for KTH continued work with impact. While studying in depth the case studies collected from each UoA, a pattern on how to structure the provided examples in a relevant pattern for KTH has emerged. This division is described later in this chapter, in case studies – examples of KTH impact and engagement with society.

The KTH impact statements

Impact statements

The impact statement should describe the UoA's approach during the assessment period to support and enable impact from research conducted within the UoA, in a context describing main types of impact and how these relate to non-academic user groups, beneficiaries or audiences. The suggested approach was to illuminate this under two headings: 'approach to impact' and 'current and future strategy and plans'. As inspiration to the formulation of impact statements, and for case selection and description, the following non-comprehensive list of types of impact – partly based on the RCUK classification of 'Pathways to impact' was given:

- Delivering highly skilled people.
- Commercialization of knowledge and research results through established or new businesses and through staff movements between UoA and industry.
- Attracting R&D investment from global business.
- Better informed public policy-making or improved public services.
- Improved patient care or health outcomes.
- Progress towards sustainable development.
- Cultural enrichment, including improved public engagement with science and research.
- Improved social welfare, social cohesion or national security.

All these aspects occur in the impact statements in RAE2012. In broad terms impact related to well-designed collaborations with external partners and over internal borders is emphasized without exception. Almost all UoAs stress that educational quality is the baseline for the most important impact: delivering highly skilled persons to external actors.

Many UoAs state that students can be essential resources for impact through project tasks and master theses and that adjunct professors and industrial PhD students are important enablers of impact as well as inspiration through their dual references. However, in this context only a few UoAs stress 'increased mobility' as an over-reaching goal.

Impact-related relations to research institutes are mentioned in about half of the statements; other relations within the Stockholm region in about a third. In almost all statements there are comments on impact for policy-makers, in Sweden as well as in the EU and other international contexts. Surprisingly many statements stress impact through activities that promote interest and ability for KTH education to pupils in pre-academic education. The same can be said about impact in broad audiences through media exposure.

About half of the statements underline relationships with institutes as important for impact. Somewhat more underline relations between research and education. Centres and other means for collaborations are mentioned as important in most statements. Sustainability and environmental issues are marked as strategically important in more than 70 percent of the statements. Words relating to policy, governmental or societal impact occur in 80 percent of the statements. Almost all statements refer to impacts through industrial relations.

The following extractions from impact statements provide examples from the different RF on how they structure their impact work in order to achieve impact and engagement with society:

RESEARCH FIELD 1: MATHEMATICS (4 UoAs)

- Cutting-edge research in more applied fields and in interdisciplinary projects.
- Organizing meetings/brainstorming activities/workshops opening up new fields.
- Continue to organize high school student and teacher activities to stimulate interest and abilities in mathematics.

RESEARCH FIELD 2: INFORMATION & COMMUNICATION SYSTEMS (2 UoAs)

- Identifying the bottlenecks of tomorrow – conduct foresight activities with industry partners.
- Increased number of industry doctoral students.
- Participation in flagship projects where the next generations of mobile networks have/are being formulated.
- Contribute in building nation-wide electronic health record systems in other countries.

RESEARCH FIELD 3: PHYSICS & THEORETICAL PHYSICS (2 UoAs)

- More activities aimed at children and high school students to stimulate interest.
- More commenting in different public bodies on impact of basic research. Outreach through lectures, articles, radio, TV.
- Challenging the industry to construct the instruments needed for physics experiments which lead to development of for example new materials and high precision instruments giving these companies an edge in the competition.

RESEARCH FIELD 4: APPLIED PHYSICS & MEDICAL TECHNOLOGY (4 UoAs)

- Focusing on interdisciplinarity to create breadth in knowledge base.
- Continue to foster the entrepreneurial spirit.
- Continue with joint industrial projects connected to MSc theses.
- Continue to have impact on standards & regulation in industry through board memberships.

RESEARCH FIELD 5: ENERGY TECHNOLOGY & ELECTRICAL ENGINEERING (4 UoAs)

- As founder of Powercircle continue to bring stakeholders in academia, industry and public sector together.
- Focus on industry doctoral students as a mean to enable mobility.
- Develop industry internal training programmes.
- Continue to work actively with impact on the European and global scene for policy-makers.

RESEARCH FIELD 6: ELECTRONICS & PHOTONICS (3 UoAs)

- Continue to participate in public policy/advisory committees.
- Continue with media exposure to broad audiences, e.g. through articles and interviews.
- Activities to promote large-scale international research centres with ties to Sweden and KTH.
- Continue collaboration with China, e.g. through established mutual centres.

RESEARCH FIELD 7: APPLIED MECHANICS (4 UoAs)

- Continue to lead the Nordic Consortium for Optimization and Control of Wind Power Parks.
- Take a leading role in the establishment of the planned Transport Science Centre.
- Outreach programmes to stimulate students in elementary and high schools.

RESEARCH FIELD 8: INDUSTRIAL TECHNOLOGY & MANAGEMENT (4 UoAs)

- Engagement in long-standing collaboration with a set of key industrial partners at Swedish and European level in both large and small/medium sized enterprises.
- Influence on general awareness and policy making regarding product innovation for a sustainable future.
- Influence the Swedish national policies on accommodation for the aged through extensive media coverage, presentations, networking and open-house approaches.
- Fostering innovation with an outreach towards the third world, e.g. innovation against poverty.

RESEARCH FIELD 9: CHEMISTRY & MATERIALS SCIENCE (5 UoAs)

- Proactively bring academia, industry and public sector stakeholders together and promote environments where competences can meet.
- Continued collaboration with companies, both domestic and international ranging from consulting to long lasting interdisciplinary projects. Means are adjunct faculty, industrial PhD and working with institutes and through centres.
- Continue to provide regulatory data for the EU REACH legislation on metals and metal oxides in relation to their health effects and environmental impact.
- Build a number of permanent demonstration stations that high school classes can visit and learn about current research areas.
- Produce popular science books that lucidly illustrate the importance of chemistry for both humans and nature.

RESEARCH FIELD 10: BIOTECHNOLOGY (4 UoAs)

- Continued patenting and exploitation of patents through own established mechanisms for outreach.
- Continue to promote build-up of multidisciplinary groups and centres addressing interdisciplinary projects and in collaboration with other universities and industry.
- Identify topics of research for which present competences and available technologies would have the greatest impact on society.
- Support the industry including start-ups and SME with infrastructure and technology for process development.
- High involvement in the Science for Life Laboratory.

RESEARCH FIELD 11: TECHNOLOGY FOR THE BUILT ENVIRONMENT (3 UoAs)

- Become an international leader of expertise to meet the challenge of modernizing fundamental societal structures.
- Emphasis on systems orientated approaches to research and innovation that focus the link between the environment and construction through long-life infrastructure and sustainability-based construction.
- Increase personnel movement/mobility between KTH and authorities/ industry/institutes with adjunct professors as important means.
- More outreach activities through media and public lectures and seminars.

RESEARCH FIELD 12: ARCHITECTURE & THE BUILT ENVIRONMENT (5 UoAs)

- Deepened engagement in planning projects at regional and national level and with stakeholders in urban development abroad/developing countries.
- Development of architectural practice and discourse to effect entry to education in the field. Extend the reach and significance of impact within the architectural profession.
- Further develop collaborations into practice and culture. Adjunct professors and platforms where research and practice can meet important means.
- Continued strong involvement in the public debate, creating effects in the policy making process.
- Prioritize research with long-term importance to society, into fundamental needs areas and to ensure that research results are used in the service of society.

RESEARCH FIELD 13: COMPUTER SCIENCE & MEDIATED COMMUNICATION (3 UoAs)

- Identifying and ameliorating threats to privacy and security.
- Evaluating and building new tools and methods to verify that software systems are correct and secure.
- More outreach activities through appearances on national TV and in newspapers.
- Influencing public policies and international standardization on usability, accessibility and human-centred design.

KTH pathways to impact

The impact statements submitted in the self-evaluation part of RAE2012 included a description of the approaches deployed by the UoAs for achieving a large impact as well as engagement with society. Through a study of the impact statements, an alternative interpretation of economic and societal impact has emerged, and a first attempt to exemplify possible ways of KTH impact and engagement with society has started to take shape as 'KTH pathways to impact' (see Figure 14). This takes into consideration the different approaches to impact and engagement with society by all UoAs at KTH. Figure 14 gives an overview of how the UoAs describe the impact their research has on society.

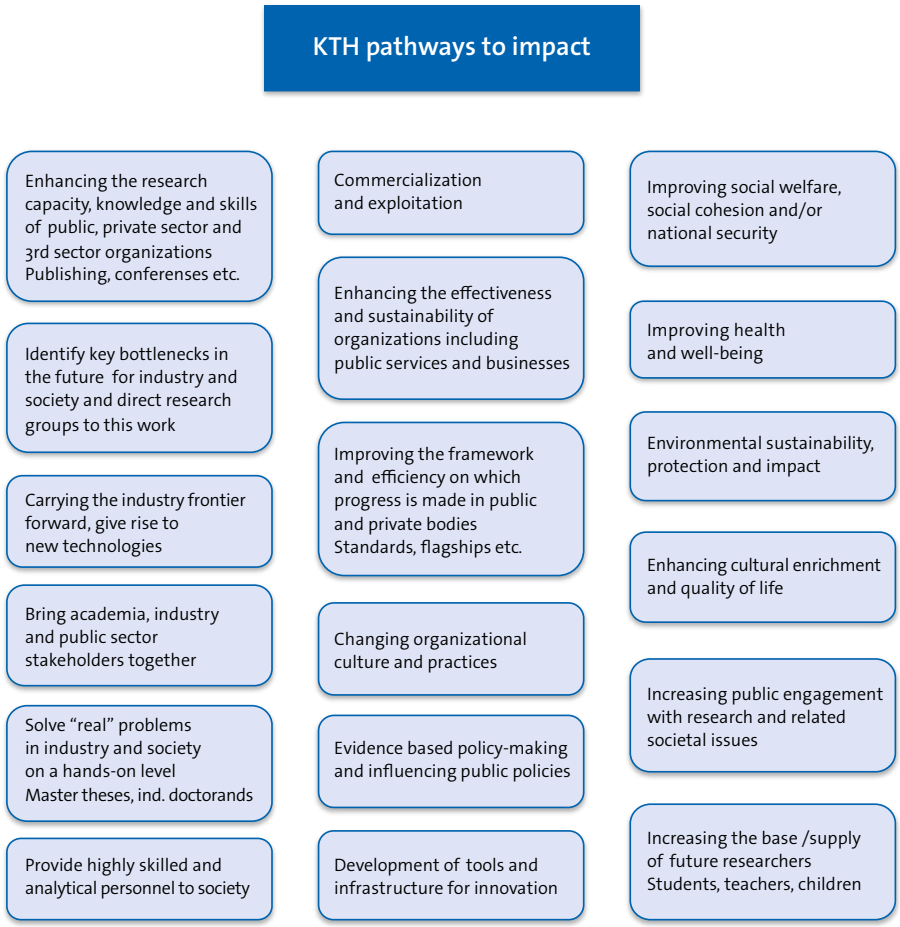


Figure 14: KTH pathways to impact.

The KTH impact case studies

Word mining of case descriptions can be useful as a vehicle to describe various aspects of impact. A rough application is shown below; specifications are given for some words with high occurrences.

OCCURRENCE OF INDIVIDUAL WORDS IN CASE STUDIES, %			
1.	**Words relating to research format:**	**72**	
	Collaboration(s), collaborative		58
	Center(s), centre(s)		33
2.	Words related to external users and partners:		
	Industry, industrial		61
	Institute(s)		34
	Government, ministry, policy makers, politicians		24
3.	**Words related to policy goals: environment, environmental, sustainable, green**	**58**	
4.	**Words related to public impact: media, newspaper(s), radio, tv**	**22**	
5.	**Business-related words: market(s). Business, sale(s), turnover**	**59**	
6.	**Words related to commercialization:**	**54**	
	Patent(s), patenting		28
	Innovation		25
	Spinoff(s), spin-off(s)		20
7.	**Words relating to geography:**		
	Stockholm		36
	China		13
	Uppsala		10
8.	**Words relating to personal resources:**		
	'PhD students' (various expressions)		51
	'Masters students' (various expressions)		15
9.	**Words relating to financing bodies:**		
	Vinnova		22
	EU		21
	Foundation(s)		21
	Council(s)		14
10.	**Some other words with high occurrence:**		
	Education		23
	Software		22

Examples of words with none or very low occurrence (max two cases) are: 'knowledge triangle', 'triple helix', 'incubator(s)', 'seed money', 'in kind' and 'gender'. License-related words occur in four cases, 'adjunct professor' in five cases, 'employment' in three. Other universities are mentioned as partners in many cases. Most frequently named of the Swedish universities, in descending order, are Chalmers University of Technology (9), Karolinska Institutet (6), Stockholm University (3), Uppsala University (3) and Lund University (3).

Foreign universities are mentioned as follows; University of Cambridge (5), Stanford University (4), University of Oxford (2), Karlsruhe Institute of Technology (2), University of California at Berkeley (1) and ETH Zurich (1).

In 62 out of 94 case descriptions there are companies named as partners where impact is realized.

	NUMBER OF CASES	DIFFERENT COMPANIES MENTIONED
Large Swedish/Sweden based companies		
Manufacturing, building	28	31
Service sector	13	13
Swedish SMEs		
With direct or indirect roots in KTH research	21	21
Other	15	21
Companies based abroad	23	45
TOTAL		**131**

Six companies are mentioned in at least five cases: ABB, Bombardier, Ericsson, Saab, Scania and Volvo. Twelve companies, all Swedish, are mentioned in 2-4 cases. All 13 research fields have case studies with named Swedish companies and 11 case studies name foreign companies, e.g.: Airbus, Alcatel, Amersham, Bayer, Danfoss, Emerson, Fairchild, HP, Nokia, Philips, Roche, Samsung, Toyota, Westinghouse. Among the 21 SMEs with roots in KTH research about half could be categorized as pure research spin-offs with established business operations. According to annual reports and home pages, the 21 Swedish companies can be classified as follows:

EMPLOYEES IN 2011/12	NUMBER OF COMPANIES STARTED				
	-1999	2000-2004	2005-2009	2010-	TOTAL
-4	-	2	4	3	9
5-19	1	2	5	-	8
20-99	2	-	-	-	2
100-	1	1	-	-	2
TOTAL	**4**	**5**	**9**	**3**	**21**

No named company started later than 2004 has grown to a size of 20 employees or more. About half of the 21 companies are in focus of a case description. A third is related to bio- and medical technology. The two companies in the descriptions with more than 100 employees are COMSOL AB (started 1990) and Silex Microsystem AB (started 2000). In 2011, they employed between them close to 400 in Sweden and abroad with a sales volume of close to 500 MSEK.

All cases contain time perspectives, giving a calendar for research roots as well as realized impacts. In some cases this calendar is contained in the case descriptions; in others, the main source of calendar information is the reference list. The table below summarizes the calendar information:

YEARS MENTIONED IN CASE DESCRIPTION AND REFERENCES, %						
	-1994	1995-1999	2000-2004	2005-2009	2010-2012	TOTAL
First year	38	20	23	17	2	100
Second year	18	22	32	25	3	100
Third year	6	26	24	36	8	100
Last year	0	0	3	13	84	100

The time aspect is important to take into consideration when looking at implementation of research, since it is often a long way to go from research at a university to the implementation. This must be considered in the development of relevant tools to enhance innovation and impact of Sweden's research on society.

In almost 40 percent of cases, the earliest research roots, mainly through reference lists, are found more than 15 years before the RAE year 2012. Looking at the third year mentioned, a perhaps more relevant time positioning for the precise roots of the impacts described in the cases, still one third of the descriptions indicate a history of more than 10 years. On the other hand, only few cases lack time references to results and impacts within the last two years. In 12 percent of the cases the time from first to last time reference is less than five years and, in 28 percent, the gap is less than ten years.

Case studies: examples of KTH impact and engagement with society

Applying the model from four UK higher education funding bodies[10] to the KTH impact cases, a two dimensional picture appears. The first dimension is subject orientated while the second is impact orientated. The categories 'improving health and well-being' and 'environmental sustainability protection and impact' become subject orientated towards 'health' and 'environment', respectively while the remaining appropriate categories are all impact orientated. By giving priority to the subject orientation one can follow different kinds of impact provided by the university within e.g. 'health'. This is a way to monitor how the university delivers different kinds of impact into subject areas that are of societal importance. Also, the subject impact can be chosen to monitor the subjects proposed in Horizon 2020, the upcoming EU framework programme for research and innovation, 2014-2020.

Regarding the impact orientation a large number of the KTH impact cases are associated with the category 'enhancing the research capacity, knowledge and skills of public, private and third sector organizations'. We have found it efficient to split this category into sub-categories to better monitor the different ways of working. Such sub-categories are, for instance, cooperation with large enterprises, cooperation with SMEs and cooperation for enhanced research in strategic areas.

The 94 impact case studies were sorted into pertinent impact categories. Roughly one-third is briefly described below. This particular selection was made to describe the different kinds of impact that originate from the research undertaken at KTH in order to get a flavour of the range of activities taken place:

CASE AREA AND TOPIC	RESEARCH FIELD
Health	
Blood pressure measurement	Electronics & Photonics
Medical imaging methods	Applied Physics & Medical Technology
Pandemic preparedness plan	Information & Communication Systems
Breast cancer detection	Applied Physics & Medical Technology
Biomedical imaging	Applied Physics & Medical Technology
Environment	
Traffic congestion charging	Technology for the Built Environment
Heat pump technology	Energy Technology & Electrical Engineering
Waste water treatment	Technology for the Built Environment

10) Research Excellence Framework, www.ref.ac.uk

CASE AREA AND TOPIC	RESEARCH FIELD
Commercialization & job creation	
Electromechanical systems	Electronics & Photonics
Scientific computing	Mathematics, Applied Mechanics
Semiconductor devices	Electronics & Photonics
Development of SMEs	
Radiation therapy	Mathematics
Mathematical optimization	Mathematics
Engagement with large companies	
Railway traction	Energy Technology & Electrical Engineering
Kraft cooking	Chemistry & Materials Science
Vehicle design	Applied Mechanics
Rock grouting technology	Technology for the Built Environment
Organizational culture and practice	
Gender balance in manufacturing	Industrial Technology & Management
Bus scheduling strategy	Technology for the Built Environment
Industrial design engineering	Computer Science & Mediated Communications
Infrastructures for innovation	
Antibody purification	Biotechnology
Fluid mechanics for papermaking	Applied Mechanics
Silicon processing	Electronics & Photonics
Electric field measurement tools	Energy Technology & Electrical Engineering
Molecular dynamics simulation	Physics & Theoretical Physics
Public policy	
Science-based chemicals policies	Architecture & the Built Environment
Research institute futures	Architecture & the Built Environment
Smart grid systems	Energy Technology & Electrical Engineering
Efficiency of financial markets	
Financial asset management	Mathematics
Insurance industry management	Mathematics

CASE AREA AND TOPIC	RESEARCH FIELD
Public outreach	
International space missions	Energy Technology & Electrical Engineering
Student solar power outreach	Applied Mechanics
Sustainable energy engineering	Energy Technology & Electrical Engineering

Health

An ultra-miniaturized pressure sensor catheter for blood pressure measurements was developed by KTH and commercialized by Radi Medical Systems AB in the late nineties. The product has become a huge clinical and commercial success. In 2008, the Fortune 500 company St Jude Inc. acquired Radi Medical Systems AB for 200 MEUR in cash to incorporate the technology into their world-leading cardiovascular product portfolio. In 2009, the New England Journal of Medicine published trials that confirmed that routine use of the device in a sensor-guided minimally invasive surgical procedure reduced mortality and myocardial infarction after one year by approximately 35 percent compared to the standard procedure, while being cost-saving, contrast agent saving, and reducing the number of stents used. Today this pressure sensing system is common medical practice and sold at a rate of more than 100,000 units per year. The Swedish production unit has approximately 200 employees and a turnover of more than 65 MEUR.

Atherosclerotic cardiovascular disease is the leading cause of death worldwide. KTH research has contributed to the development of tissue Doppler-based imaging methods (TDI) for the assessment of myocardial variables allowing for objective quantification of cardiac movement patterns. The research led to a patent that was sold to GE Healthcare. Today the software exists in different forms in nearly all echocardiographic equipment available on the market. A large number of clinical studies are also using the TDI applications. The clinical usefulness of TDI applications in both research and daily practice is rapidly increasing.

Spatially explicit scenario-based simulation studies can be used in forecasting events affecting public health e.g. pandemic preparedness, where no experiments or trials involving a real population can be carried out. KTH researchers in this field were involved in writing the Swedish pandemic preparedness plan, and to initiate deep studies into the forecasting of pandemic H1N1 influenza. The results were publicly disseminated and also used by policy makers, state epidemiologists, and medical professionals in Sweden.

Women at the age of 40 to 75 years of age in most industrialized countries are screened for breast cancer at regular intervals using mammography. KTH researchers have invented

and developed a detector technology implying that the radiation dose can be reduced by around a factor of 2 with better or equal image quality as conventional systems. A spin-off company, Mamea Imaging AB, was started in 1999 and the development was continued in cooperation with the industrial partner Sectra AB. In 2004 the company was fully acquired by Sectra AB which in turn sold it to Phillips in 2011.

For the use in biomedical imaging, a liquid-metal-jet x-ray source, with the potential of several orders of magnitude higher brightness while still operating at the power levels of present sources, was developed and patented by KTH researchers. As a result the spin-off company Excillum AB was founded in 2007. At present the company employs 10 people and has good prospects to go cash-flow positive 2012. Markets outside the biomedical imaging market have also been identified.

Environment

The Stockholm Congestion Trial 2006, encompassing a full-scale congestion charging system and extended public transport, was to a large extent planned, designed and evaluated by KTH-associated researchers. The trial resulted in the introduction of permanent congestion charges from 2007 onwards. The system has reduced the number of vehicle entering/exiting the inner city by over 20 percent during weekdays and is estimated to produce annual social benefits of over 70 MEUR per year. KTH researchers have continued to evaluate the system and suggested improvements to it. As experts they that been involved in designing evaluation congestion pricing schemes elsewhere (Ho Chi Minh City, Bogota, Gothenburg, Copenhagen) and acting as expert advisors to many governments and cities all over the world (e.g. the United States, the United Kingdom, the Netherlands, Norway, Finland, Indonesia, China, South Korea, Hungary).

Sweden is by far the country in the world that has the largest number of heat pumps per capita. The one million heat pumps of Sweden absorb about 18 TWh of renewable energy from ambient space each year, and deliver about 27 TWh of heat to individual houses and district heating systems. The cold climate, abundant hydropower and nuclear power together with lack of fossil fuels contribute the basis for such a position. However, the success of heat pumps is also a result of the successful research done at KTH in close collaboration with industry and thereby contributing to the unique position of the Swedish heat pump manufacturers. The Swedish heat pump manufacturers are amongst the largest in Europe and through these companies Swedish research has international impact.

For wastewater treatment, particularly for phosphorus removal and recovery, a porous filter material was developed from 1995 to 1998 at KTH resulting in the product Polynite®. In 2006 the spin-off company Bioptech AB was founded based on the intellectual property rights. The company turnover for 2012 is estimated to be 8.5 MSEK based on its business activities in Sweden, Finland, Poland, Malaysia, China, and North America.

Commercialization and job creation

Silex Microsystems AB is the world's largest pure-play micro-electromechanical systems (MEMS) foundries providing large-volume advanced MEMS and heterogeneous packaging production services. The company was founded in 2000 by former PhDs at KTH. The success of the company very much relies on the technology skills developed by the founders when they were staff members at KTH in the late nineties. The business is based on the very same fabrication techniques that constitute the core of the research activities at KTH. Several of the products manufactured by Silex have their origin from research at KTH. Silex has more than 190 employees and a turnover of 35 MEUR.

COMSOL AB is a recognized player in the worldwide scientific software arena. Its product, the COMSOL Multiphysics finite element simulation environment, was developed in the mid- nineties in close cooperation with KTH. The COMSOL software has a unique capability in the unified treatment of models with different types of physics. This has made COMSOL a strong candidate for businesses in recently developed applications such as micro-electronics, micro-fluidics, fuel cells, and electromagnetic fluid-structure interaction. COMSOL AB and Inc. together employ around 140 people and enjoy a corporate turnover growth rate exceeding 15 percent per year.

In 2005 the spin-off company TranSiC AB was founded around a unique semiconductor device with extremely low switching losses for a device with a breakdown voltage of 1200V. Continued research was made in collaboration with the company and the Swedish research institute, Acreo. Finally in 2011 the product portfolio was so interesting that one of the major semiconductor producers, Fairchild Semiconductor, acquired the entire business for 17 MUSD. Fairchild is almost the only manufacturer with this type of device in its portfolio.

Development of SMEs

KTH has an extensive collaboration with the Stockholm-based medical technology company RaySearch Laboratories AB. RaySearch was founded in 2000 as a spin-off from Karolinska Institutet. The very core of RaySearch products is an optimization module for radiation treatment of cancer, so-called intensity-modulated radiation therapy (IMRT). IMRT is a case where use of optimization has had a very significant direct impact. The quality of treatment is improved drastically by use of mathematical optimization methods. RaySearch has grown to become a major player on the world scene. Today, the company has almost 100 employees worldwide and has had a close cooperation with KTH since the start.

Optimization Partner is a small spin-off company from KTH founded in 2000. The company is focused on consulting services based on mathematical optimization. KTH transfer mathematical optimization knowledge that gives a direct impact on society materialised by the clients of Optimization Partner.

Engagement with large companies

A very successful collaboration was established between KTH and Bombardier Transportation AB within the Swedish Centre of Excellence in Electric Power Engineering (EKC^2) financed by the Swedish Energy Agency. The development of high-efficiency permanent magnet drives for railway traction was started in 2007 and is still on-going. In the collaboration, KTH was carrying out research focused on the development of early stage prototypes, later stage prototype systems as well as control and system related research on prototypes very close to series production. The company has had two record orders of permanent-magnet equipped trains to be delivered to France and Switzerland. In summary, the research collaboration has resulted in a substantial contribution to Swedish industry and to the development of high efficient drive systems for railway traction.

The development of 'compact cooking' is an excellent example of how a machine supplier, a university and a customer in the form of a pulp mill can cooperate to develop a new product. For the pulp mill the driving force was an improved quality of the end product and resulted in the base for a totally new *kraft* cooking concept. The cost reduction for the new system was more than 50 percent. By 2012, more than 30 digesters have been sold worldwide producing more than 20 million tonnes of pulp each year with the new cooking concept. The new concept has resulted in improved product quality, large operational and capital cost savings, less environmental impact in the form of lower energy consumption and less bleaching chemicals demand.

Within the context of vehicle design a concept of multi-functionality was demonstrated in a panel on the roof of a Saab 9-3 Sportwagon. The demonstrator showed the possibility to design an integrated panel while simultaneously meeting functional constraints on load bearing capacity, acoustic performance, dynamic response, assembly, weight and cost. In the full-scale demonstrator the feasibility of the design philosophy and the concept of multi-functionality were proven resulting in system level impacts such as reduced roof component weight by 60 percent, number of parts by 80 percent, thickness required for the roof by 50 percent and a subjective evaluation of the acoustic performance with gave superior results. The additional cost associated with the roof was estimated to 5 EUR as compared to the standard assembly.

The ingress of water to rock tunnels and/or under hydro-power dams founded on rock is a major problem with infrastructure constructions in rock. In cooperation with industry, road and railway authorities and the Swedish Nuclear Fuel and Waste Management Company, KTH has initiated research to improve the grouting technology of rock masses in order to get more predictable results. The method was implemented during the construction of the Stockholm commuter tunnel, Citybanan, and has reduced the grouting time by more than 20 percent and with ingress of ground water well below the acceptable limits. The relative economic impact is thus very high. KTH researchers have also served as grouting experts and panel members for several international hydropower projects in the Dominican Republic, Laos, and Greenland.

Organizational culture and practices

As a classical car manufacturer the Volvo Group is a company dominated by men. KTH researchers have carried out several research- and development projects at Volvo Group, addressing women managers and different initiatives aiming to enhance the situation of women in the organization. The work has had a direct impact on the gender equality work of the company as well as an indirect impact on the number of women managers within the company worldwide. During the years of cooperation, the number of women in the Volvo Group executive team increased from 0 to 19 percent, the number of women in executive positions is higher than the percentage of women employees, and the company has significantly more women as managers compared to the manufacturing industry in general in Sweden (23 percent compared to 16 percent). The Volvo Group has today a state-of-the-art diversity work in its operations all over the world as for instance in France, Japan, China, and Brazil.

Traditionally bus services are based on schedule adherence criteria. Advances in ICT however, enable the development of control strategies based on richer criteria e.g. holding buses at stops using a criterion aiming to equalize headways. This strategy showed a lot of promise from the passenger and the operator perspective. A field test of the concept over one month was performed using one of the high demand lines in Stockholm. The test was carried out in cooperation with the Stockholm Public Transport agency, the City of Stockholm, the public transport operator Keolis, and the drivers' union. The test resulted in an improvement of 20 percent in service, a reduction of 10 percent in passenger waiting times, and a more uniform distribution or passenger loads. The social welfare gains due to reduced waiting times were estimated at 2 MSEK. Drivers also reported less stressful working conditions and expressed their universal approval of the strategy. Preparations for a full-scale implementation of the strategies on all high-frequency bus lines in Stockholm are currently undergoing.

KTH researchers participated in the founding of the Scandinavian tradition of collaborative design. This is a methodology in which the actual end users actively participate on equal terms as developers in the design and construction of the information technology support and the subsequent organization of work that the approach promotes. The integration of the methodologies into the software engineering processes led KTH researchers to defining key principles for user-centred systems design. These principles have been extensively used, translated into various languages, such as Chinese, to help promote the methodology in other parts of the world. One of the major impacts has been on the formulation of and research in relation to the role of usability professionals in the industry.

Infrastructures for innovation

KTH researchers have actively worked to develop efficient and cost-effective platforms for industrial purification of therapeutic antibodies. Monoclonal antibodies are widely used in therapy today and are currently the second largest category of biotech drugs

on the market; a multi-billion dollar market. The commercial success of the antibodies has led to a great need for efficient ways to purify antibodies. The impact from KTH researchers concerns the protein engineering and development of affinity proteins suitable for robust high-throughput antibody purification and labelling as well as the commercialization of these technologies together with one of the leading biotech companies, GE Healthcare. A rough estimate is that more than half of the antibodies today approved for human use or in clinical trials have been produced using the technology developed by KTH researchers.

The CAPPI laboratory (Centre for Advanced Process and Product Innovation) carries out fundamental fluid mechanical studies aiming at providing knowledge that can be applied to improve papermaking or to make new materials from wood-based raw materials. By applying technologies spurred from the fundamental fluid mechanical studies, KTH researchers have shown that paper for newspapers can be produced with a 20 percent reduction in raw materials and energy without sacrificing the core product properties. Recently KTH researchers have developed a processing method that enables production of a very well-controlled fibre out of nano-fibrillated cellulose. The fibre turns out to show excellent tensile strength properties and is thought to be useful in textile and engineering (composites) applications.

The experimental research focused on building up a strong infrastructure for state-of-the-art silicon processing has made by KTH researchers being major players in European research in the area. An important part has been establishing the clean room infrastructure capable of up to 200 mm wafer processing putting the KTH researchers as a leading node in European networks regarding clean room services, and able to perform a majority of processing needed. KTH has also sold processing of entire batches to other universities in Europe, e.g. VTT in Finland, and spin-off companies.

KTH researchers hold a front-line position in space electric field measurements enabling KTH to build complete electric field instruments in-house, tailored for missions of variable sizes. NASA selected the KTH measurement system for its Magnetospheric Multi-Scale mission, to be launched 2014, with a budget of 1,000 mUSD. NASA is financing fabrication and tests of 16+2 flight units. The Swedish National Space Board funding of the KTH participation, which amounts to about 2 mUSD, constitutes 0.2 percent of the mission budget, which is a modest cost for participating in the most advanced magnetospheric mission ever flown.

Molecular dynamics simulation is one of the most promising techniques for studies of atomic scale properties in materials and life science research. KTH researchers have been active in this method development and the open source software GROMACS has turned into one of the most widely used computational chemistry codes in the world. Besides, GROMACS is the main engine of the Folding@Home project, the world's largest distributed computing effort with half a million clients. GROMACS also increase the performance of supercomputers by a factor of 2-5 and is effectively saving hundreds of millions of dollars in computing worldwide every year.

The KTH team is the only group outside of Japan that has been invited as a member of the RIKEN life science team in charge of the Kei computer at Kobe (the world's largest computer). Most major pharmaceutical companies use GROMACS and the KTH team is working directly with companies like Cray and AMD. The Swedish company Synective Technologies AB is using it for Field-Programmable Grid Array (FPGA) processor acceleration, and NVIVIA Inc is collaborating with the KTH team on the acceleration of graphics processing units. The GROMACS software also comes preinstalled on every Playstation 3 console. A major reason for this strong impact has been the free availability of the code.

Public policy

In close cooperation with philosophers, toxicologists, ecotoxicologists and environmental chemists, KTH researchers have engaged in the development of science-based chemicals policies. The development has been performed in three programmes. The first was devoted to developing basic principles, the second to general implementation and the third to further developments and implementations for active pharmaceutical ingredients. The programme has a clear influence on the new European legislation for chemicals (REACH) but it also plays an active part in the development of governmental strategies, reports and governmental processes, and there is a good forecast for this to continue.

Research on the Swedish innovation systems at KTH resulted in the conclusion that state policy needed to change direction, especially for the Swedish institute sector. The policy advice gained a follow-up when the Ministry of Industrial Development commissioned KTH to conduct a public enquiry on the institutes with advice on their future. The report was delivered in 2006 and was, after the general election that same year, taken over by the new government where preparations for advice continued with a new report that by and large followed both the analysis and the advice in the KTH report. Based on the advice, the government decided on substantive changes for the partly state owned institutes, including a new holding company with wider authorities (RISE), a new funding system giving the institutes direct funding through RISE, systematic increases in funding, a clear directive to operate on the European market. The level of basic funding has risen which has made new initiatives possible, including better performance on European R&D markets and a significant general rise in turnover.

Research at KTH within the general area of power systems, and especially the work on renewable production and the importance of power system information models, has made it possible for KTH researchers to take an active role in bodies having an impact on national and international policy making within the 'smart grids' field. For example, KTH researchers have actively participated in the drafting of mandate 490 on standardization for smart grids later issued by the European Commission, the Swedish legislation concerning how to handle peak load capacity and different rules/tariffs for integrating new renewable energy such as wind and solar power, in the development

of the IEC Standardization Roadmap for smart grids, in work within the International Energy Agency concerning wind power integration and through these activities also contributing to Swedish policy making within the smart grids field.

Efficiency of financial markets

In 2003 a KTH researcher suggested a risk-based robust asset allocation tool that accounts for possible fat-tailed asset classes. This resulted in a robust optimizer that turned out to be very useful in turbulent market conditions. Since 2004, the suggested asset allocation optimizer has been implemented and developed primarily by an hedge fund, and is generating consistently higher returns than the five percent top hedge funds within the so-called 'systematic macro strategies' especially in turbulent market conditions. The underpinning research was within stochastic optimization problems for fat-tailed processes that were solved for a class of processes that turned out reminiscent to the historical behaviour of earlier financial data.

Together with the insurance companies Folksam and Skandia Liv, KTH researchers are aiming at developing new approaches for better risk modelling and management in non-life insurance and life insurance. The insurance industry faces challenges in the implementation and development of new approaches to measurement and management of risk as part of new regulatory requirements. A particular challenge is the requirement to model and manage the aggregate risk for a company as a whole. Addressing this question requires both a deep understanding of the insurance business and advanced methods and models from the theory of stochastic processes and multivariate analysis, and the skilled use of estimation techniques.

Public outreach

KTH researchers participate in the first international space mission for multi-probe exploration of the Sun-Earth connection, Cluster. The mission involves over 60 research groups from Europe and USA. The KTH contributions have improved the understanding of key space plasma processes producing aurora on Earth and other planets, of benefit for space science and of great interest for the general public eager to learn about the phenomena behind, for instance, the northern lights. The results were published in Nature with follow-up articles in Science, Nature, New Scientist, Der Spiegel and in the daily press including USA Today, DN and SvD. The cluster aurora research at KTH has been recognized to a wide community by invited lectures, press conferences, popular articles and lectures.

The Sustainable Energy Engineering (SEE) MSc programme at KTH was established in 1997 with significant support by the Swedish International Development Agency (SIDA) in terms of scholarships. SEE has hosted over 700 campus-based students from over 70 different countries during its 15 years of operation. In terms of innovation in teaching, it was the first comprehensive distance-based MSc programme at KTH offered to students at partner universities in Africa, Asia, and South America.

The programme has clear and immediate impacts in terms of capacity building in developing countries as employers are keen to upgrade staff competence, and such programmes are not available locally and/or in flexible learning modes. The programme has received a high level of visibility in developing countries, as acknowledged by government officials including ambassadors and ministers from Brazil, Bolivia, Ethiopia, Mauritius, Mozambique, Rwanda, Sri Lanka, Tanzania, USA and Zambia.

Space Solar Power (SSP) is proposed as a solution for the future needs for new green energy sources. The technologies required to make SSP feasible include among other things a large scale in-orbit construction where KTH participates. The technology for the large scale in-orbit construction has been chosen to be demonstrated through student space projects. Teams of students were formed from KTH, Gothenburg University and Stockholm University and worked towards the launch of the space web deployment experiment. The student space project also involves an extensive outreach program, where the students present the project to pupils in primary and secondary schools, and to the general public through newspaper articles.

Concluding observations

The review of KTH research from the point of view of societal and sector impact has been an important element of RAE2012, along with an increased attention to the scope of academic impacts. The aim has been to take steps towards a full assessment of the academic, economic and societal impact of KTH research. RAE2012 is part of a continued process of deepening the understanding of KTH research qualities in at least two respects, internal quality development to provide incentives to further boost research performance, and raising the external awareness of the multitude of research outputs from KTH.

There are three constituent parts of this continued process of systematic quality work. The first one has the main objective to evaluate the RAE process together with the UoAs and KTH schools. The second is to address the question of the choice of methods of performing the impact study within the RAE process. The method has been to ask each UoA to formulate their strategy as regards impacts, including a SWOT analysis, providing depth by submitting cases typical of the impacts that they have attempted to generate. The third element of the method has been to ask international peers to judge the performance in parallel with the scientific and research environment aspects. Furthermore, RAE2012 has included a major effort to collect comparative quantitative information on research processes and research performance across all of KTH.

This work can be seen as a first step towards a broadened view on process and method to evaluate research where scientific quality is balanced against qualities concerning sectoral and societal impacts. Such evaluations are normally performed by external funding agencies in relation to research projects and research programmes, funded both nationally and internationally. Examples would be the recently launched governmental strategic research programmes and the excellence centres created via among others VINNOVA and the EU 7th Framework Programme. In RAE2012 KTH has demonstrated the ambition to systematically address these quality issues for the whole university as the main performer of technical research and development in Sweden.


ELEKTRO
TEKNIK

CHAPTER 4. BIBLIOMETRIC ANALYSIS 2004-2011

Scientific activities can be monitored using a variety of measures. Various university ranking lists are published periodically where selected indicators are used to compare the performance of universities worldwide. Some of these indicators are related to bibliometric analysis. In RAE2012 we have engaged self-evaluation and peer review in the analysis; we have also performed an analysis of the publication and citation data held in the KTH publications database, DiVA.

Common bibliometric indicators for university ranking were monitored from different university ranking perspectives. The perspectives monitored were publications, impact, and collaboration. Also the data were investigated with regard to gender. The RAE2012 bibliometric analysis was researcher-based. This means that all publications within the period 2004-2011 from each researcher employed at KTH, and registered in DiVA on our bibliometrics census date of February 14th 2012, were included in the investigation. Publications originating from earlier employment, e.g. previous university affiliations were thus also included.

University ranking lists, on the other hand, are affiliation-based, meaning that the articles are counted as 'belonging' to a university. Hence, a researcher-based study is a measure of an organization's capacity on any particular census date, while university ranking lists are based on the output from a specific organization.

Many of the major university ranking organizations, e.g. the Times Higher Education World University Rankings, the Shanghai Jiao Tong Ranking, the Higher Education Evaluation & Accreditation Council of Taiwan as well as the Leiden Ranking system refer to the Web of Science (WoS) database. The WoS database was thus also chosen for use in RAE2012[11]. The selected indicators are described fully in Appendix E.

11) Certain data included in this report are derived from the Web of Science® prepared by Thomson Reuters®, Inc. (Thomson®), Philadelphia, Pennsylvania, USA: © Copyright Thomson Reuters® 2012. All rights reserved.

Methods used

Publication records were retrieved from the KTH publication database DiVA, for the period 2004-2011, using a unique KTH author identification number. Records were retrieved regardless of the author affiliation registered in DiVA. Citation indicators are based upon publications from the period 2004-2010. Records can be entered into DiVA from both WoS (a process performed by KTH library) and also manually by KTH researchers where gaps in the records occur. For RAE2012, records were quality controlled for KTH author ID and the unique WoS record ID number, if applicable.

WoS was used as the primary source for the citation count, journal and subject data as well as author and address data used for the collaboration indicators. The bibliometric system at Karolinska Institutet (KI) was employed for field comparative data, i.e. for the calculation of the field normalized citation rate, the field normalized impact score of each journal, and the share of publications among the 10 percent most cited in the field. The KI bibliometric system contains all the indexes provided by Web of Science except for the conference indexes. Full counts were used for the calculation of most indicators, including the field normalized citation rate.

Summary of indicators

A summary of the bibliometric indicators used in RAE2012 is shown below. For more complete information, please see Appendix E.

DENOTATION	DESCRIPTION
P_{DiVA}	The total number of publications in DiVA published 2004-2011. The number gives an indication of the total production of the unit.
P_{WoS}	The number of publications in Web of Science published 2004-2011 (articles, reviews, letters, proceeding papers). This is the number of publications which is the base of all indicators with Web of Science as the source and 2004-2011 as the time period.
P_r	The author fractionalized number of publications in Web of Science is the sum of an analyzed unit's share of authors of the retrieved publications from Web of Science. Low values in relation to the number of publications in Web of Science (P_{WoS}) indicate a high level of co-authors.
p_{WoS}	The Web of Science visibility is the percentage of the unit's publications which are present in Web of Science compared to publications (all the document types included in the RAE) in DiVA. If this indicator shows a low percentage the unit publishes in sources that are not covered by Web of Science and the results of the Web of Science based indicators should therefore be interpreted with caution. (2004-2011)
P_C	The number of publications in Web of Science published 2004-2010, i.e. the number of publications P used for citation counts C.
p_{cf}	The share of publications used for the calculation of field normalized citation rate is the percentage of the unit's publications found in the bibliometric system at Karolinska Institutet.
P_{lev2}	The number of publications published in level 2 journals (2004-2011), as categorized by the Norwegian research evaluation system. 20% of the journals are categorized into level 2 by the Norwegian system. The indicator shows how many publications that have been published in high quality journals.
j_{cf}	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 is cited on average 20 % over the respective field norms. Hence, the indicator shows the average citedness of the journals of publication.
C	The total number of citations in Web of Science to publications published 2004-2010.
C_r	The author fractionalized number of citations in Web of Science is the sum of an analyzed unit's share of citations to publications published 2004-2010. Low values in relation to the number of citations (C) in Web of Science indicate a high level of co-authors.
c_{py}	The average number of citations per publications and year gives an indication of the citedness adjusted to the time of publication. (2004-2010)
c_f	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 on average 20 % over the respective field norms. (2004-2010, articles, letters, review articles)
p_{top10}	The share of publications among the 10% most cited in the field shows the percentage of highly cited publications within the field of publication. (2004-2010)
a_p	The average number of authors per publication. (2004-2011)
i_p	The average number of unique countries per publication. (2004-2011)
p_i	The share of publications co-authored internationally. (2004-2011)
p_u	Share of uncited publications in Web of Science. (2004-2010)

Publications

Journal articles and conference papers were the most popular type of publication in this evaluation. There were 2,030 peer-reviewed articles published in 2011 (as registered in DiVA) and 1,474 conference papers. Chapters in books and reports were the next most common type, with 187 and 189 items published in 2011, respectively. However, publication practices differ between research fields. The publication indicators used to characterize the KTH publication outcome for the period 2004-2011, and the calculated results, were:

INDICATOR	
Publications in DiVA, P_{DiVA}	26,367
Publications in Web of Science, P_{WoS}	14,001
Publications in Web of Science, author fractionalized, P_r	6,006
Web of Science visibility, p_{WoS}	53%
Publications used for the citation counts, P_C (WoS) (2004-2010)	12,151
Publications used for the calculation of field normalized citation rate, p_{cf} (2004-2010)	44%
Journals' field normalized impact, j_{cf} (KI, 2004-2010)	1.25

Web of Science covered 53 percent of the eligible KTH publications and the KI bibliometric system 44 percent. It is likely, however, that WoS does not cover all the main publications channels typical for a technical university such as KTH.

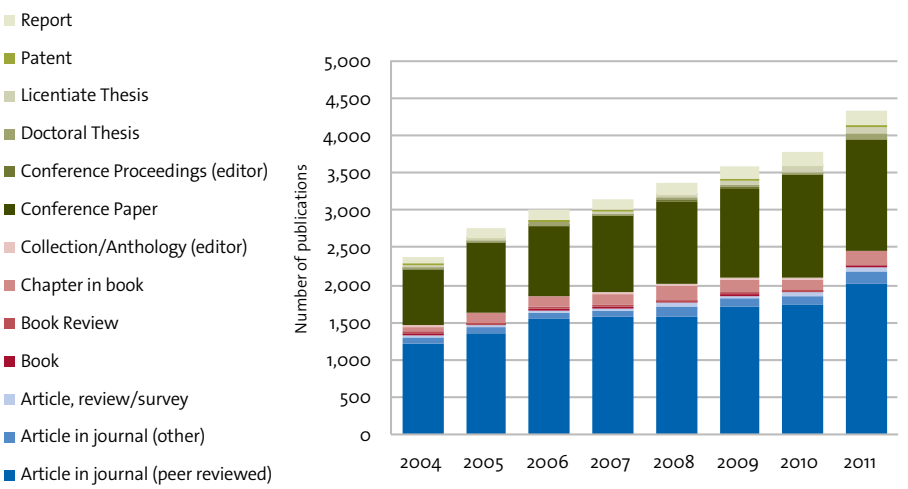


Figure 15: Publications in DiVA published 2004-2011 by KTH researchers.

The most common subject area in WoS was 'engineering' with 15.7 percent of the publications categorized into that area. An overview of the most frequently occurring subject areas for KTH publications is as follows (the differences in coverage of WoS should be considered when looking at these results, however):

SUBJECT AREA	% SHARE	SUBJECT AREA	% SHARE
Engineering	15.7	Mechanics	2.0
Physics	15.0	Environmental Sciences & Ecology	1.8
Chemistry	7.7	Polymer Science	1.7
Materials Science	7.6	Energy & Fuels	1.6
Computer Science	5.9	Metallurgy& Metallurgical Engineering	1.5
Optics	4.4	Automation & Control Systems	1.5
Telecommunications	3.1	Nuclear Science & Technology	1.4
Science & Technology - Other topics	2.4	Astronomy & Astrophysics	1.2
Mathematics	2.4	Instruments & Instrumentation	1.1
Biochemistry & Molecular Biology	2.4	Other	19.6

The top ten journals or proceedings used by KTH researchers when publishing, and which are also visible in Web of Science, were:

JOURNAL/PROCEEDINGS	COUNT	JOURNAL IMPACT (j_{CF})
Physical Review B. Condensed Matter and Materials Physics	297	1.39
Physical Review Letters	248	2.96
Lecture Notes in Computer Science	235	no data
Applied Physics Letters	190	1.53
Optics Express	141	1.74
Journal of Applied Physics	127	0.83
Proceedings of SPIE. the International Society for Optical Engineering	125	no data
Journal of Chemical Physics	124	1.17
Langmuir	118	1.40
Journal of Nuclear Materials	104	1.30

Publication impact

The impact indicators are influenced by the coverage of the database used, in this case Web of Science. In general those UoAs with a good visibility in WoS quite naturally have better possibilities to obtain greater impact in the same database. From the impact indicators shown below, the average field normalized citation rate (c_f) of 1.29 for the period implies that, on average, KTH publications visible in WoS are cited 29 percent over the corresponding field norm.

IMPACT INDICATORS (2004-2010)	
Citations, C (WoS)	120,744
Citations, author fractionalized, C_r (WoS)	39,142
Citations per publication and year, c_{py} (WoS)	2.1
Average field normalized citation rate, c_f (KI)	1.29
Share of publications among the 10% most cited in field, p_{top10} (KI)	13%
Uncited publications, p_u (WoS)	24%

The sliding 3-year average field normalized citation rate (c_{f3}) of items published by KTH researchers has, in fact, increased somewhat from 1.18 to 1.42 between 2004 and 2010, see Figure 16.

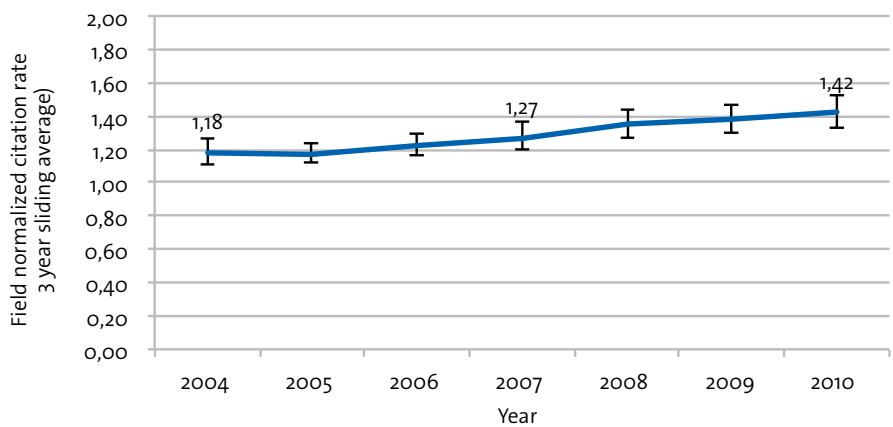


Figure 16: Time series of 3-year sliding averages of the field normalized citation rate (c_{f3}). The value of e.g. 2007 is an average of the field normalized citation rate for publications from 2006 to 2008. The instability of the data set is represented by bars.

Large scale collaborations (50 to 3,220 authors) account for most of this increase of the average field normalized citation rate. Such differences should be interpreted with caution since they could be serendipitous. Nevertheless, the high number of publications on the aggregated level of all of the publications included in RAE2012, and the rather sharp increase of the field normalized citation rate in 2007, indicates a factual rise of the field normalized citation rate in 2007.

Publication collaborations

The collaboration indicators used demonstrate some clearly distinguishable changes taking place between 2004 and 2011 regarding the researchers' collaboration patterns. More publications were co-authored by larger groups in 2011 than in 2004. The share of publications with two or three authors has declined, while the share of publications authored by moderately large groups of researchers (4-10 people) has grown, as well as publications published by large groups of authors (10 authors up to as many as 3,220 authors). The number of sole-authored publications was consistently low, at about five percent.

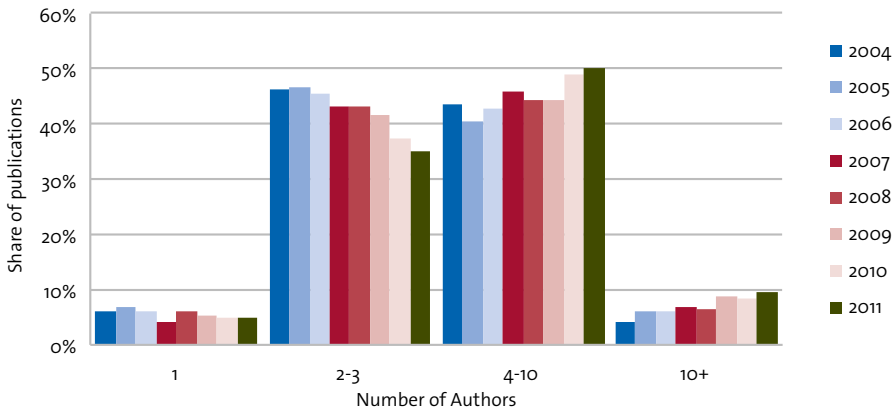


Figure 17: Number of authors per KTH publication (2004 to 2011), based on Web of Science records.

Another growing trend is that of international co-authorship, which increased from 37 to 50 percent of publications being co-written with scientists from outside of Sweden during 2011 compared to 2004. The USA, China and Germany were the most commonly occurring countries with which KTH co-authors, the share occurring with China having grown most noticeably from slightly below 4 percent in 2004 to around 8 percent in 2011.

Gender perspective

The number of female researchers constitutes roughly 25 percent of the total number of researchers in RAE2012, see Figure 18. There are no substantial differences between the impact indicators of female researchers compared to their male colleagues, see Figure 19-Figure 21. On the contrary, the performance of female and male researchers is very similar when it comes to field normalized citation rate and share of publications among the 10 percent most cited within the relevant field. The quality of journals, measured by the journals' field normalized impact indicator, is as well roughly the same for both men and women.

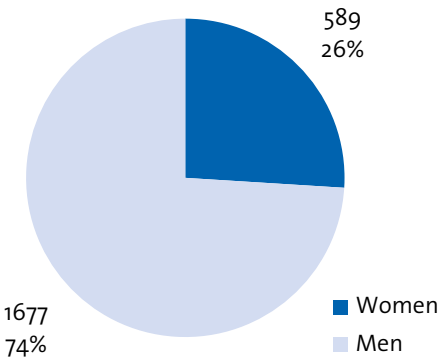


Figure 18: Number and share of all female and male researchers included in RAE2012.

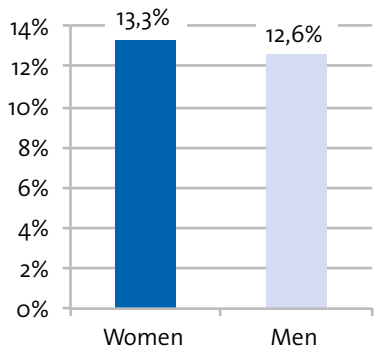


Figure 20: Share of the publications among the 10 percent most cited (p_{top10}), compared to publications within the same research field, published the same year and of the same document type, based on records in the KI bibliometric system.

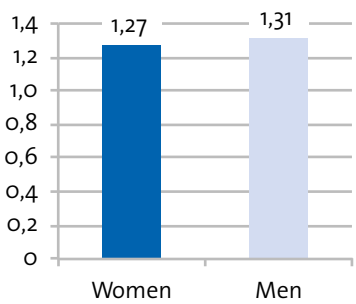


Figure 19: Average field normalized citation rate (c_f) for publications published 2004 to 2010 by female and male KTH researchers.

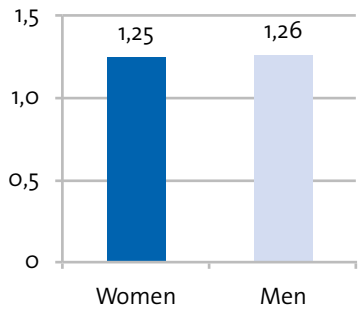


Figure 21: Journals' average field normalized impact (j_{cf}) for publications published 2004 to 2010 by female and male KTH RAE2012 researchers, based on records in the KI bibliometric system.

The main bibliometrics results per unit of assessment are reproduced here, organized according to each research field (see Appendix E for a full description of indictors used):

UoA	# OF RESEARCHERS	P_{DiVA}	P_{WoS}	P_r	p_{WoS}	P_c	p_{cf}	P_{lev2}	j_{cf}	c	c_r	c_{py}	c_f	p_{top10}	p_u	a_p	i_p	p_i
1.1 – Mathematics	38	382	329	199,4	86%	295	82%	123	1,24	1186	703,8	0,8	1,12	10%	24%	2,2	1,6	49%
1.2 – Mathematical Statistics	10	102	67	26,1	66%	58	64%	30	1,34	324	115,2	1,2	0,83	7%	24%	3,6	1,7	58%
1.3 – Optimization & Systems Theory	6	206	117	49,5	57%	104	37%	39	1,26	587	242,7	1,1	1,14	12%	31%	2,7	1,3	30%
1.4 – Numerical Analysis	16	204	100	54,2	49%	85	49%	43	1,45	1135	531,6	2,4	2,32	20%	17%	2,5	1,6	43%
2.1 – Information Processing, Networking & Control	52	1739	1004	518,4	58%	868	24%	245	1,36	3312	1617,2	0,8	1,32	13%	58%	3,1	1,3	19%
2.2 – Communication – Services & Infrastructures	41	879	428	187,8	49%	383	18%	53	1,05	778	278,8	0,4	0,96	5%	67%	3,7	1,2	21%
3.1 – Experimental Physics	15	762	679	62,3	89%	575	88%	233	1,68	12541	578,9	6,3	2,52	23%	10%	477	12,4	89%
3.2 – Theoretical Physics	17	314	273	130,3	87%	241	86%	129	1,52	6055	2329,6	4,9	1,80	17%	10%	3,3	1,7	50%
4.1 – Applied Physics & Medical Imaging	37	819	601	241,0	73%	524	61%	258	1,35	5462	1730,0	2,0	1,16	11%	20%	4,9	1,5	35%
4.2 – Medical Technology	28	502	260	94,9	52%	226	50%	42	0,83	1436	475,1	1,3	0,59	3%	19%	4,9	1,5	36%
4.3 – Materials Physics	21	493	451	117,0	92%	384	82%	192	1,41	4412	922,6	2,3	1,26	16%	16%	6,4	1,9	61%
4.4 – Optics & Photonics	10	494	408	150,9	83%	360	64%	193	1,35	3330	1220,7	1,9	1,35	15%	29%	4,6	1,7	52%
5.1 – Nuclear Power Safety, Reactor Physics & Reactor Technology	19	421	192	69,0	46%	161	45%	32	1,01	1173	423,8	1,6	1,26	15%	22%	5,9	2,3	55%
5.2 – Electrical Power Engineering	45	1362	784	348,9	58%	705	42%	253	1,14	4512	1537,5	1,3	1,16	12%	35%	3,5	1,5	43%

UoA	# OF RESEARCHERS	P_{DiVA}	P_{WoS}	P_r	P_{WoS}	P_C	p_{cf}	P_{lev2}	j_{cf}	c	c_r	c_{py}	c_f	p_{top10}	p_u	a_p	i_p	p_i
5.3 – Fusion & Space Plasma Physics	19	536	416	107,6	78%	365	73%	37	1,06	3202	583,4	1,7	1,18	12%	14%	9,9	3	77%
5.4 – Energy Transformation	18	451	187	80,7	42%	137	34%	51	1,17	979	427,3	1,6	1,11	14%	27%	3,7	1,5	40%
6.1 – Microsystems Technology (MEMS)	10	309	160	86,0	52%	144	27%	45	1,71	1207	477,7	1,7	1,44	11%	33%	5,4	1,3	19%
6.2 – Integrated Devices & Circuits	18	590	503	181,2	85%	461	64%	141	1,02	2665	777,3	1,1	0,91	5%	29%	5,7	1,5	35%
6.3 – Embedded Electronics & Computer Systems	12	608	291	150,1	48%	259	10%	12	0,74	318	171,6	0,2	0,52	4%	70%	4	1,1	13%
7.1 – Vehicle Engineering	43	711	249	140,5	35%	207	31%	38	1,09	834	454,8	0,8	0,94	9%	25%	2,7	1,2	17%
7.2 – Solid Mechanics	15	326	230	126,6	71%	198	67%	55	1,14	2226	1159,4	2,2	1,30	14%	14%	2,9	1,5	37%
7.3 – Fluid Mechanics	32	568	344	198,2	61%	294	52%	142	1,20	1812	1022,2	1,3	1,23	13%	30%	3,2	1,3	25%
7.4 – Mechanics-Biomechanics	8	129	72	45,2	56%	62	54%	16	0,95	368	165,3	1,3	0,72	2%	21%	3,2	1,5	22%
8.1 – Industrial Product Development	38	591	136	69,5	23%	118	15%	10	0,99	513	251,6	0,8	0,95	8%	42%	3,2	1,2	18%
8.2 – Production Engineering	19	190	48	25,2	25%	45	12%	5	0,80	81	48,2	0,4	0,63	0%	56%	4,2	1,1	8%
8.3 – Health (Ergonomics; Health & Building)	20	283	77	20,3	27%	71	28%	18	0,99	709	196,3	1,8	1,07	7%	10%	4,6	1,2	16%
8.4 – Industrial Economics & Management	45	859	89	47,4	10%	80	9%	20	1,07	441	200,3	1,3	1,24	10%	29%	2,8	1,3	26%
9.1 – Chemistry	60	1321	1140	420,7	86%	1000	86%	462	1,30	13531	4665,3	3,0	1,30	12%	6%	4,5	1,6	46%
9.2 – Chemical Engineering	31	503	353	144,4	70%	301	63%	147	1,27	3033	1040,2	2,0	1,06	10%	15%	3,7	1,4	29%
9.3 – Fiber & Polymer Technology	41	948	704	300,4	74%	597	75%	135	1,38	8686	3077,7	3,1	1,59	18%	9%	4,2	1,4	31%
9.4 – Theoretical Chemistry	10	520	498	161,9	96%	429	95%	226	1,28	5065	1523,9	2,4	1,12	10%	8%	5,1	2	74%

UoA	# OF RESEARCHERS	P_{DiVA}	P_{WoS}	P_r	P_{WoS}	P_C	p_{cf}	P_{lev2}	j_{cf}	c	c_r	c_{py}	c_f	p_{top10}	p_u	a_p	i_p	p_i
9.5 – Materials Science & Engineering	38	1126	986	356,7	88%	836	86%	458	1,23	8350	2557,0	2,0	1,10	9%	16%	4,8	1,9	57%
10.1 – Medical Biotechnology	22	302	261	67,5	86%	223	89%	81	1,42	8697	1600,1	7,6	2,12	30%	2%	8,7	1,6	35%
10.2 – Industrial Biotechnology	17	154	98	24,4	64%	84	63%	15	1,07	1392	323,6	3,2	1,17	8%	4%	5,7	1,6	46%
10.3 – Proteomics	22	321	258	77,6	80%	220	82%	76	1,49	5159	1296,6	4,8	1,75	24%	7%	10,1	1,8	38%
10.4 – Materials Biotechnology	16	205	166	45,9	81%	136	82%	67	1,50	2745	639,3	4,1	1,73	21%	2%	7,1	1,7	53%
11.1 – Civil & Architectural Engineering	27	577	99	59,1	17%	82	14%	23	0,98	199	116,1	0,6	0,69	6%	37%	2,5	1,2	20%
11.2 – Land & Water Resources	26	667	293	113,8	44%	253	40%	86	1,12	2486	766,1	2,0	1,19	11%	13%	4,3	1,9	47%
11.3 – Transport Science	33	832	181	80,7	22%	156	18%	53	1,09	647	324,1	0,9	1,08	10%	31%	3,1	1,4	35%
12.1 – Architecture	26	500	14	10,2	3%	14	3%	8	0,53	4	3,5	0,1	0,14	0%	79%	1,9	0,9	14%
12.2 – Real Estate & Construction Management	14	245	26	15,0	11%	23	12%	8	1,04	125	57,0	1,2	0,96	4%	13%	2,3	1,5	35%
12.3 – Philosophy & History of Technology	27	1249	155	117,7	12%	133	12%	59	1,07	914	487,6	1,7	1,14	9%	22%	2,5	1,1	8%
12.4 – Urban Planning & the Built Environment	56	992	207	135,0	21%	159	18%	68	0,79	1360	716,0	1,7	0,99	8%	20%	2,7	1,2	15%
12.5 – Industrial Ecology	9	193	40	16,9	21%	37	18%	12	0,98	261	76,1	1,3	0,75	3%	30%	3,6	1,3	25%
13.1 – Theoretical Computer Science	21	284	125	67,5	44%	109	19%	20	1,21	329	166,3	0,6	0,58	2%	39%	2,7	1,2	16%
13.2 – Applied Computer Science	51	1050	465	212,1	44%	420	27%	76	1,32	2710	890,3	1,3	1,10	11%	38%	3,7	1,4	24%
13.3 – Mediated Communications	26	542	88	42,6	16%	80	8%	24	1,06	348	144,3	0,9	1,67	18%	49%	3,6	1,3	11%

Conclusions

RAE2012 included the use of indicators commonly used as bibliometric indicators by university ranking organizations. The selected indicators represent parameters such as publications, impact, and collaboration. It was observed that KTH has made progress in all these areas.

Peer reviewed journal articles and conference papers constitute the major publication channels for KTH researchers. However, out of the total number of publications from KTH, only 53 percent is visible in Web of Science. In certain fields the coverage of WoS is very low which of course influences all bibliometric indicators in that field.

From a university ranking perspective, this means that technical universities like KTH show an academic profile that is not well covered by databases such as Web of Science. This is of course a disadvantage compared to universities with an academic profile more adapted to the WoS coverage. It is important to keep such effects in mind when comparing universities from a bibliometric perspective.

KTH also shows improvement in publication impact. Although the fractionalized average field normalized citation rate has been constant during 2004-2010 the non-fractionalized average field normalized citation rate, and the share of publications among the 10 percent most cited, has increased significantly during the period. Also the collaboration indicators have developed in a positive way. The number of authors per publication, the share of publications co-authored internationally, and the number of countries per publication are all indicators that have increased during the period. It is also noteworthy that the growing number of research collaborations KTH has with research groups in China has resulted in a substantial increase in the number of co-authored publications between the two countries.

There are no major differences in the research output of male or female researchers when it comes to impact. The field normalized citation rate, share of 10 percent most cited publications, and the journal field normalized impact rate are roughly the same for both male and female authors.


KUNGL TEKNISKA HÖGSKOLAN

CHAPTER 5. SUMMARIES OF THE PANEL REPORTS

UoA summary profiles

UoAs exhibit different patterns of resource input and research output. The three categories, research output, impact and engagement, and research environment were chosen as key aspects to be covered in the RAE2012 assessment. This chapter presents a summary profile of each UoA, using quantitative indicators within the three categories, and data derived from the RAE2012 database. Figure 22 shows data drawn from 2011 presented with six indicators.

The first indicator in Figure 22 is the share of external funding in the total turnover for 2011. This gives an indication of the ability of the UoA to attract external resources for research in a competitive environment. The second indicator is a measure of the degree of journal publication activity in 2011 of the UoA's academic faculty in terms of the number of publications normalized by the total amount of academic faculty in 2011. The third indicator represents the average field normalized citation rate (c_f) for WoS publications (in this case between 2004 and 2010). These three indicators represent important parts of the research quality category.

The fourth indicator, impact publications, measures the total number of publications in 2011 via channels other than journals and conference papers, such as paper collections, books, chapters in books and research reports. Also collected from each UoA was the number of popular science publications and lectures to the public and media appearances, but these were not included in the publication count.

The fifth indicator provides a measure of the visiting or fixed-term staff in relation to the academic faculty. In the category visiting or fixed-term staff we include visiting professors, adjunct professor, fixed-term appointed researchers and research assistants. The purpose is to provide a measure which shows the level of activity in external linkages in the research environment. The sixth indicator shows the presence of PhD education in the UoAs by measuring the degree of production in relation to the amount of academic faculty in 2011.

Figure 22 below shows the KTH average of each of the six indicators. The ensuing set of figures for each UoA represents the situation in 2011 of that UoA in relation to the KTH average for each one of the indicators.

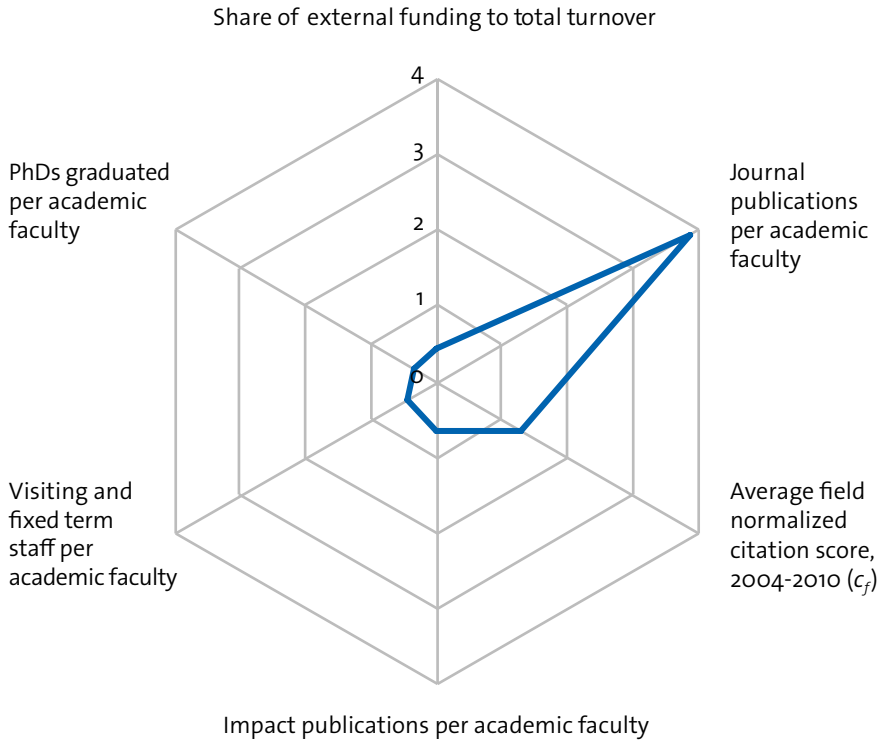


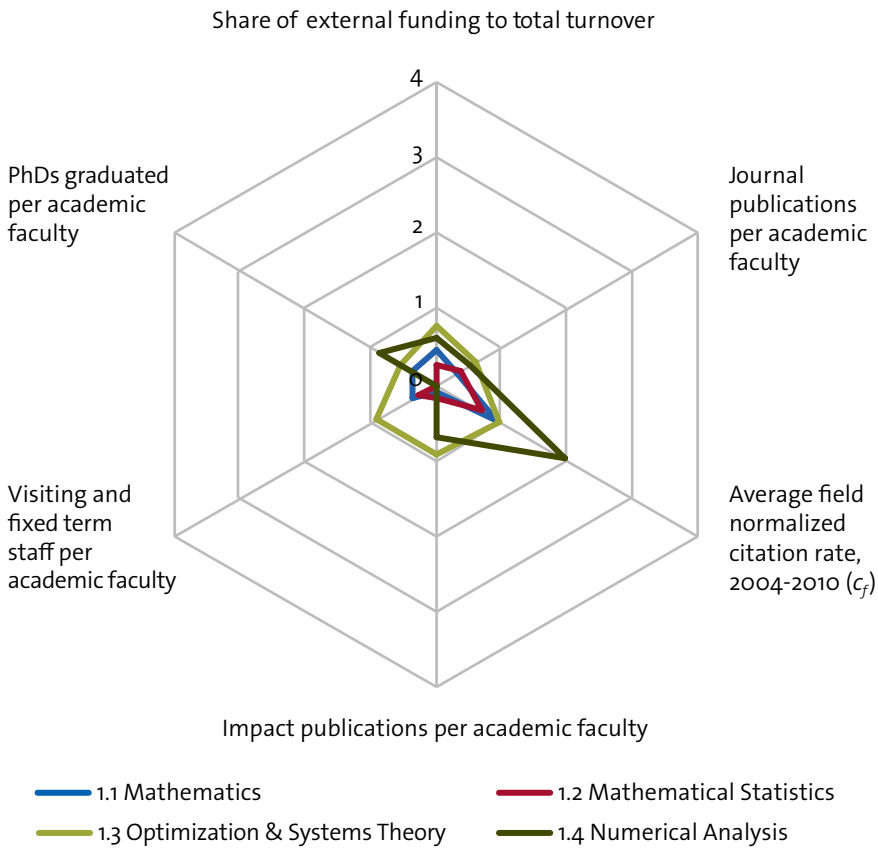
Figure 22: KTH research profile 2011. *Data from 2011 except where indicated.*

Figure 22 shows that, averaged across UoAs, the share of external funding compared to total turnover in 2011 was 0.43. Around four (3.9) journal publications were produced per academic faculty in 2011. The average field normalized citation rate (c_f) was 1.29 for the period 2004-2010. Impact publications averaged 0.65 per faculty member, i.e. equivalent to an average of two impact publications per academic every three years. It might be noted that this means the share of other publications to the total number of publications was about one to six. As shown in the following figures of this chapter, this share varies considerably across UoAs.

The number of visiting and fixed-term academic staff in relation to permanently employed academic faculty averaged 0.45 across UoAs in 2011, implying that there was close to one visiting or fixed-term person for every two permanent faculty members. Finally, the number of doctoral students graduating each year in relation to the number of permanent faculty averaged 0.36 implying that, for every three faculty members at KTH, one PhD will graduate each year.

Each of the following spiderweb diagrams represents individual UoA results for 2011 relative to the averages shown in Figure 22 above. Thus, a value of 1 indicates that the UoA performed at a level equivalent to the average for 2011, e.g. a 1 for "journal publications per academic faculty" is equivalent to 3.9 publications per faculty member for that UoA.

Expert panel 1: Mathematics



The research field of mathematics consists of four units of assessment with a distinct and joint focus on basic research. The research field stand out in the KTH context in that all indicators except one have values below the KTH average. The average field normalized citation score for numerical analysis is double the KTH average.

Unit of assessment 1.1: Mathematics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

This is an exceptionally strong unit, which is among the best of the comparable mathematics programmes in the world. Research is of high quality, and graduate education is top notch. Members of the unit are innovative in their use of mathematics

with applications in industry and society. The leaders in each research area are young and dynamic and provide an excellent research environment. Every research group within this UoA produces world-class, highly original research, and several individuals are world leaders in their fields. The entire panel was deeply impressed by several of the recent results, which are having a great impact in their respective fields. The productivity of the unit is excellent. Numerous publications authored or co-authored by researchers have been published in leading journals. The members of this unit frequently give invited addresses at international conferences. The unit attracts visitors and collaborators from top institutions worldwide. Numerous faculty and students in the unit have made significant contributions to industry and society. The unit is very active in the dissemination of mathematical ideas to the general public and in raising young students' interest in mathematics. The clear and efficient management structure is very conducive to collegiality. The unit manages to attract excellent graduate students who are very pleased with their working conditions. Given the tremendous research calibre of the faculty, however, the panel was struck by the relatively low number of graduate students. The proximity to the Institut Mittag-Leffler, an internationally recognized research institute, benefits both the unit and the institute. Building on their current and traditional strengths, the unit proposes future research directions that are highly innovative and very promising. The panel believes that capitalizing on the strengths of the researchers in numerical methods in the division could also amplify the outstanding research in these directions. The numerous prizes granted to young researchers clearly indicate the presence of young stars.

Unit of assessment 1.2: Mathematical Statistics

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

This is a strong unit, with significant connections to the financial and health industries. The research is of very good quality and the graduate education is excellent. The unit produces a considerable number of masters students who easily find jobs in industry. The panel was impressed by the research of the unit's young members on both theoretical and applied aspects of managing the Swedish electric grid. The statistics group has greater strength in theory than in applications. Currently the unit collaborates closely with financial institutions in Stockholm, which also fund graduate students. A large number of masters students are supported by this funding. The collaborations with the medical community are also genuine and substantive. Until recently the number of PhD students was surprisingly low, but the situation is improving.

The unit makes considerable effort to disseminate research results to the general public. Moreover, they organize an annual seminar in financial engineering for the financial sector, academic researchers and students in the Stockholm region. The unit collaborates at a substantial level with industry in Sweden and the greater European area. The panel found the structure of the research environment of the unit somewhat opaque. The unit clearly needs more professors, but this hiring must be accompanied by a clear and realistic strategy for the future. The graduate students were content, expressing satisfaction with the atmosphere and working conditions. They are very optimistic about their employment prospects.

Unit of assessment 1.3: Optimization and Systems Theory

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

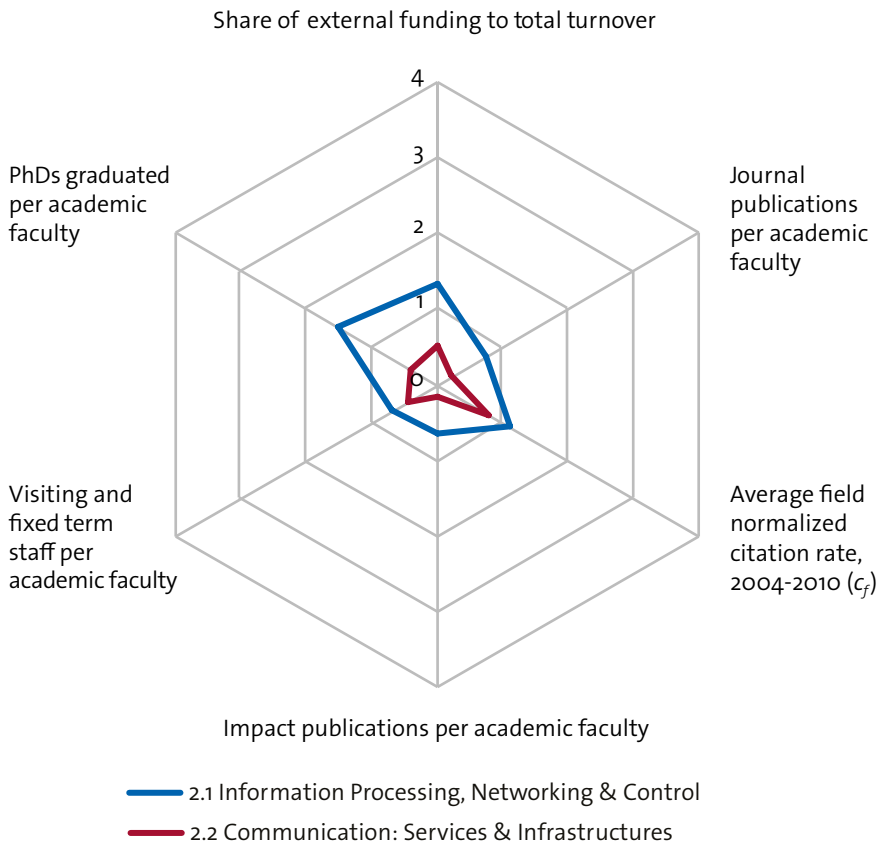
This is an exceptionally strong unit, which makes highly significant contributions to both theory and practice. The research is of world-class quality, and the graduate education is excellent. With more stable funding structure and more faculty members, the unit could move to the next level of excellence. This UoA is very small but nevertheless produces world-class, highly original research, and includes international leaders in the field. The productivity of the unit is excellent. Numerous publications authored or co-authored by researchers have been published in leading journals. The members of this unit frequently give invited lectures at international conferences. The unit attracts regular visitors and collaborators from top institutions worldwide. The unit's work on the moment problem has had great impact on both speech recognition and a wide variety of practical spectral estimation problems. Their research in numerical optimization has direct applications in radiation treatment of cancer. The company RaySearch employs the unit's algorithms for radiation therapy that is applied successfully in more than 2,000 clinics worldwide. The unit has obtained considerable student support from industry. The panel encourages the unit to make a greater effort to disseminate their accomplishments to the general public. The panel found the structure of the research environment somewhat opaque. The unit clearly needs more professors, but this hiring must be accompanied by a clear and realistic strategy for the future. The graduate students were content, expressing satisfaction with the atmosphere and working conditions. They are very optimistic about their employment prospects. This unit, which already has an impressive track record, has great potential for continued achievement in research and applications. Their future success critically depends on their ability to grow and to attract high quality faculty.

Unit of assessment 1.4: Numerical Analysis

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

This is an exceptionally strong unit, which makes highly significant contributions to both theory and practice. The research is of world-class quality, and the graduate education is excellent. With more stable funding structure and more research faculty, the unit could move to the next level of excellence. The next few years will be critical as this unit moves into the mathematics division, and the panel is very optimistic about the future synergies. Research output is outstanding both in its quality and volume. The unit is led by dynamic world leaders still in their prime and has managed to hire a number of highly promising young researchers in the field. Productivity is excellent. Numerous papers authored or co-authored by researchers of the unit have been published in leading journals. The members of this unit frequently give invited lectures at international conferences. The unit attracts regular visitors and collaborators from top institutions worldwide and maintains strong ties with commercial software companies (COMSOL AB, Efield AB). The Efield software product relies heavily on the research developed within this unit. The unit is also very active in disseminating its research through projects such as FEniCS. The unit has obtained student support from industry. The panel encourages the unit to make a greater effort to disseminate their accomplishments to the general public. The leadership is young and dynamic. Their vision and plan for the future is well formulated and precise. The research environment will improve with future hires. The panel is very optimistic that the move of this unit into the mathematics division will enhance the research environment for both the unit and the mathematics division as a whole. The graduate students were content, expressing satisfaction with the atmosphere and working conditions. They are very optimistic about their employment prospects. This unit, which already has an impressive track record, has great potential for continued achievement in research and applications. Their future success depends rather critically on their ability to grow and to attract high quality faculty.

Expert panel 2: Information & Communication Systems



The research field consists of two units of assessment with congruent profiles. Most indicator values fall below the KTH average. The unit of information processing, networking & control has a profile toward PhD student staff and external funding in the KTH context.

Unit of assessment 2.1: Information Processing, Networking & Control

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The panel concluded that this UoA is a world class group with the potential of becoming a world leader in the areas of communications, control and networking.

It consists of talented and energetic researchers whose interests span the full breadth of these areas and who are spearheading a new approach towards a holistic, integrated view of the communication process that incorporates the control and multi-user aspects. The research programme is of the highest quality; it has the potential of high impact, and is conducted in an environment that is vibrant and conducive to high morale, motivation, and productivity. The UoA has the potential to set the agenda of research in the field of complex systems that combines physical layer issues with control and networking. There is ample and voluminous evidence of excellent research published in the highest quality journals. Citation levels are impressive, funding is healthy and diverse, and the faculty and research staff enjoy a world-class reputation. Patents, spinoff companies, high visibility collaborations at national and international levels, competitive awards, successful funding and successful placement of its graduates round up the unit's achievements. The quality of the research could be further improved if a strategic plan with quantitative goals is developed within the UoA and if the organizational structure within which it operates is restructured in a more rational fashion. There is a concentration of talent across all levels of status and age groups that has the potential to propel the group to the highest levels of achievement. Gender balance is not yet at satisfactory levels although the international mix of backgrounds is truly impressive. The potential for cooperation with other units where comparable areas of research are pursued is high. Increased effort to place graduates in academic positions will increase the prestige of the unit even further. The UoA delivers well trained graduates to a broad range of industries of national importance to Sweden. The dissemination of the research findings is effective and well-coordinated. There is an active programme of exchanges and collaborations that enhances the potential for significant impact of the UoA's research beyond national boundaries through extensive and successful collaboration with outstanding individuals and institutions around the world. In particular, the ACCESS Centre constitutes an invaluable framework for the unit. The recent award and establishment of the TNG programme is another positive development that will not only improve the research environment but will also enhance the potential for cooperation with other units.

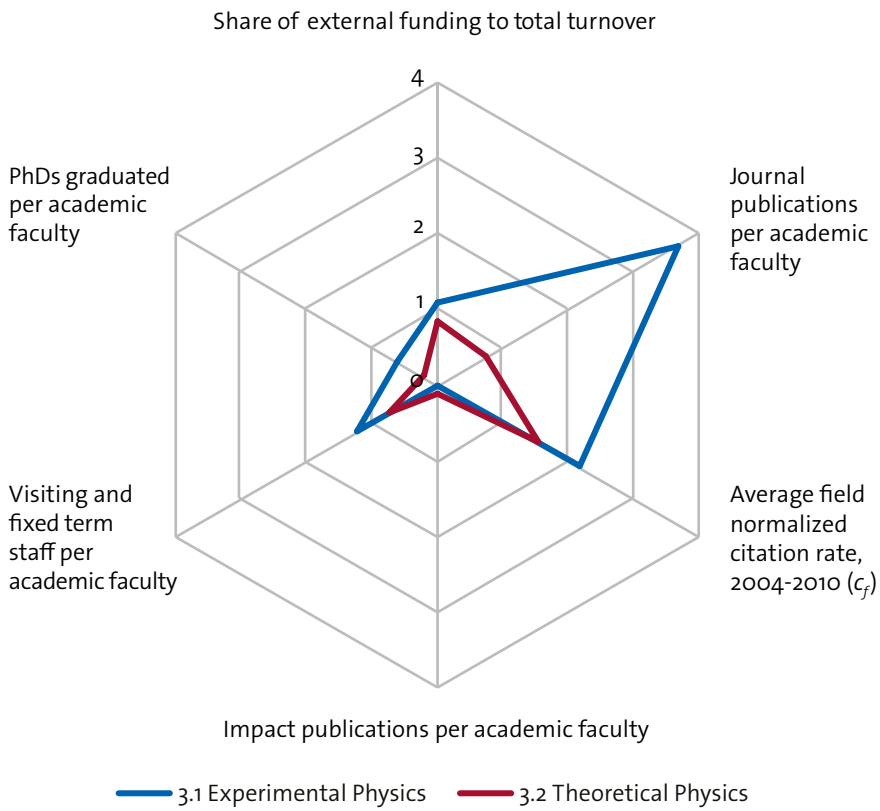
Unit of assessment 2.2: Communication: Services & Infrastructures

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

This UoA includes two very heterogeneous components that have practically nothing in common. By contrast, each component overlaps with counterparts in other units within KTH. The research programmes undertaken within the UoA appear mostly orientated towards responding to immediate and future industry needs and are

definitely of a more applied nature. Their quality is mixed. There are several subgroups of the research staff who pursue high-calibre work and who are exceptionally productive. At the same time there appear to be several who are not directly contributing to the research. Outputs from the UoA have been of high significance to industry but the strong dependence on Ericsson represents a risk. The environment within the unit presents a mixed picture as well. The presentation of the material in both the written and oral forms was not very informative or effective and thus the assessment of quality proved quite challenging. It is a question of institutional judgment, philosophy and policy as to whether to sustain the heavily applied nature of the programme and its close ties to industry. There are definite advantages to doing so as there are risks. There is evidence of high quality research of a high risk and foundational nature (also in the form of open software products, patents and spinoff efforts) but there is also absence of activity on the part of several members of the staff. The level of funding is strong but has a fragile component due to the close ties to Ericsson. Nonetheless it is diversified and includes new significant opportunities in the form of the EIT and the TNG programmes. Unquestionably, the research in this UoA has had significant impact on industry and society at large. There is a unique opportunity for the unit to take advantage of the TNG programme in which it is a participant.

Expert panel 3: Physics & Theoretical Physics



Both units of assessment within the research field exhibit a high productivity in publication in relation to the KTH average. The unit of experimental physics combines a high intensity of publication with field normalized citation scores three times above the KTH average.

Unit of assessment 3.1: Experimental Physics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

In spite of consisting of only a few relatively small groups, this UoA is taking leadership in international world-class research. The unit is doing work at the very forefront and

is in a leading position in several different areas. One such area is the search for the Higgs boson, where although part of a very large superteam at the CERN Large Hadron Collider, they are one of relatively few institutional teams assuming a leadership position. A second area of strength is in balloon- and satellite-based astroparticle physics, where KTH scientists are again assuming leading roles in international efforts. The experimental nuclear physics effort is also functioning at a very high level, making significant leading-edge contributions. A concern is that the research environment is fragile, because the teams in experimental physics are quite small relative to those of peer institutions. The research environment is obviously good enough to enable excellent leading-edge work, but not sufficiently robust to ensure the continuation of work at that level. There are notable outreach efforts such as educational outreach utilizing cosmic ray counters and the Radioactive Orchestra that creates music from nuclear decay. There is good knowledge exchange with industry, patents have been filed by members of the UoA relating to new techniques for medical imaging, and their students represent a highly-trained workforce which is snapped up by industry. We note, however, that the impact on technology by basic research of the type done in this unit tends to be long range (decades timescales). Based on the history of basic physics and subsequent technological development over the last century, such impact is inevitable; this basic research represents the seed for the applied research of the future. There is enormous potential for expansion of the unit's cosmic ray detector work into a permanent network that will allow the unit to perform more extensive, long-term experiments, gain a deeper knowledge of science and technology, and interact with schools both in Sweden and overseas (where such networks already exist).

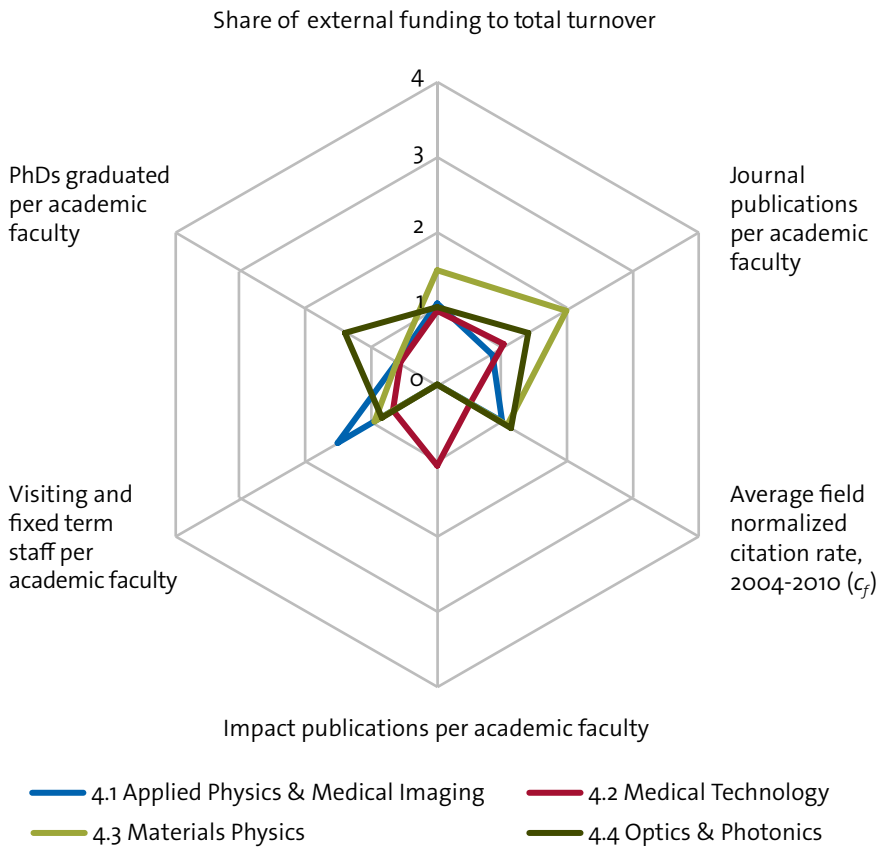
Unit of assessment 3.2: Theoretical Physics

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

In the biophysics area, the work is the best in the world within its own mission of biomolecular simulation. However the field of biomolecular simulation has not yet contributed in a paradigm-shifting way to either physics or basic or applied biology. In the other areas of theoretical physics in this UoA, the work is being published in the most high impact journals possible and has paradigm-shifting potential, but the quantity of the work does not match the quality. There are major contributions to impact but they are not paradigm-shifting. For the theoretical physics group, as with the experimental physics group, approximately 50 percent of the graduates opt for industrial careers with good jobs, showing that industry values the problem-solving skills that the students gain. The software product of the biophysics team has become

the molecular simulation tool of choice for the pharmaceutical industry and is also the underlying tool for Folding@Home, a worldwide distributed computational protein-folding enterprise. A notable current impact in a non-biophysics area has been the contribution of the theoretical physics group to the dialogue over materials to be used for long-time disposal of nuclear waste. In the longer term the work on strongly interacting electron systems, which is the prime focus of the KTH condensed matter theorists, is likely to be a foundation for the next major leap in electronics, namely quantum electronics. While the timetable for implementation of quantum electronics is uncertain, the ultimate rewards from a leading position in the basic science underlying this field, both economically and in terms of scientific prestige, will be large. The UoA is quite active in various outreach activities, such as giving popular science talks, organizing the series of open lectures at AlbaNova, and a recently increased number of popular science publications. In terms of intellectual ideas and research opportunities, the environment in theoretical physics at KTH is vibrant for students and post-docs. The broad applicability and increased interest in the application of molecular simulations to challenging life science problems, will no doubt increase the impact of the biophysics team over the coming years. Overall, the UoA is well positioned to exploit the fundamental theoretical connections between particle physics and condensed matter physics.

Expert panel 4: Applied Physics & Medical Technology



The units of assessment within the research field are homogenous in their profiles in relation to the KTH context. The journal publication rate is twice the KTH average in the unit of materials physics. The profile of the unit of medical technology is more pronounced with regard to impact-related publications than the rest of the units.

Unit of assessment 4.1: Applied Physics & Medical Imaging

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The research groups of the UoA have published about 60-75 peer reviewed scientific papers annually, a substantial number of them in the highest impact factor journals, like Science, Nature Communications and Nano Letters. In addition, during the assessment

period the UoA has filed more than 20 patents and patent applications, which is an extraordinary large number for one unit. The UoA is performing world-leading fundamental research in several areas of applied physics (biomedical & x-ray physics, biomolecular physics, cell physics, laser physics, nanostructure physics, quantum optics) and medical imaging as reflected by their top level publications. The combination of excellence in these core fields together with an entrepreneurial spirit provides an excellent base for future growth. The quality of the science and the impact on and engagement with society is exceptional. The strong leadership has resulted in a dynamic, well interacting UoA, which has resulted in a substantial increase in funding. New recruitments have addressed the balance of gender issue thus creating a very attractive environment for students and ensuring the future vitality of the department. The vision of combining research in the bio-opto-nano area will carry well into the future. This builds well on the unique opportunities offered by the collaboration of KTH and Karolinska Institutet, including the exciting new Science for Life (SciLifeLab) project. The evident success in basic science and the entrepreneurial spirit fostered within the unit has provided the foundation for creating spin off companies, some of which are world leaders in their respective fields. This concept provides a solid base for prosperity well into the future. The unit is well balanced in age and gender and has been able to attract substantial external funding and an exceptional number of prizes, especially also for the development of young faculty. The plan to include a faculty appointment with medical background will provide additional strength to the bio-opto-nano concept. They have taken excellent care of their young talent, resulting in five junior and mid-level faculty appointments.

Unit of assessment 4.2: Medical Technology

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The UoA has made several appointments in new fields expanding the scope of this unit and especially has been very successful in acquiring substantial amounts of external funding, including several European projects and a significant private donation, supporting their research programme. Their main asset is the focus on medical innovation in combination with an engineering/technological background, leading to a high number of patent applications and spin-offs. The unit has created a large number of spin-off companies and a broad range of applications with a large potential impact on society. It has the consistent ambition to change established medical procedures, for example using advanced ultrasound imaging methods, and thus avoiding the risk associated with cardiac catheterization for a large number of patients or in another programme changes in the procedure for patients with a head trauma. If successful,

the impact on society will be huge. The new senior level faculty recruitments complement and extend existing research efforts, creating a very attractive environment for students. The structural biology group has also been successful in establishing a node as one of the national facilities for structural biology. The unit needs to develop a strategic plan that will carry them over the next 10 to 20 years. They should include those areas, where there is considerable expertise within KTH. For the long term future the link between basic engineering and the medical field should be strengthened, including an improved access of engineers to the medical environment at Karolinska Institutet. The UoA is still largely bi-modal in terms of age and there are deficits with gender distribution. For the longevity of the unit intermediate-age, high-quality faculty appointments are needed with a focus on research output quality and gender balance. A better integration of the different disciplines, as well as a tightening of the links with other engineering research groups at KTH and beyond, is needed to tackle the complex problems in healthcare and find the best solution.

Unit of assessment 4.3: Materials Physics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

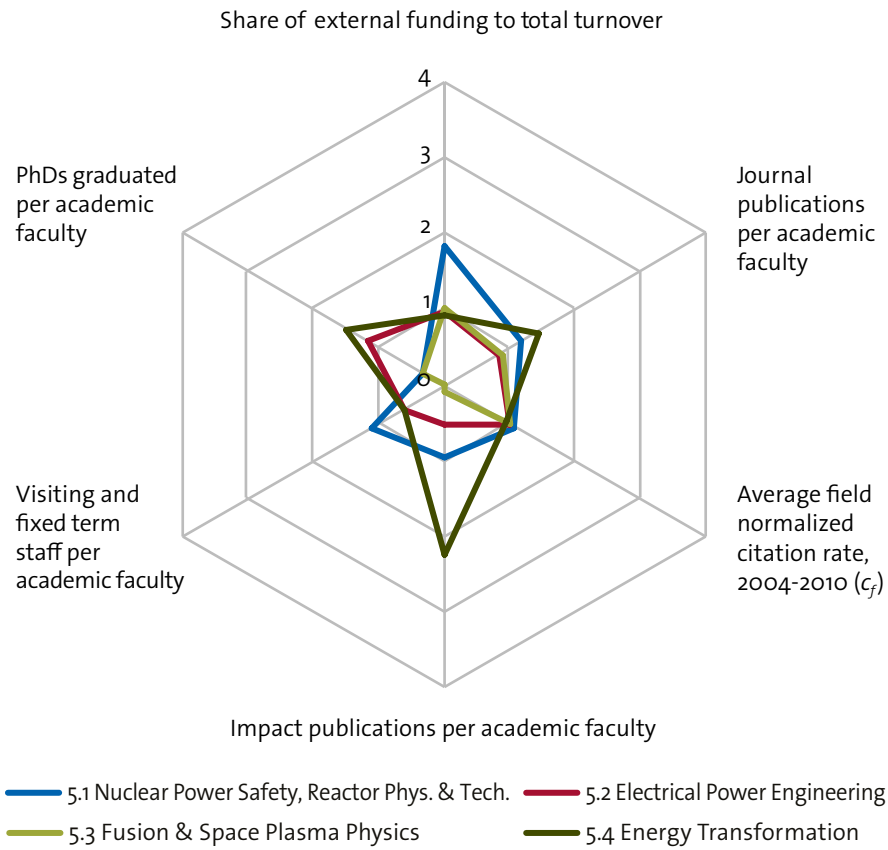
The quality of the science in this unit is excellent with an impressive number of publications in the highest profile journals. The impact on and engagement with society is well recognized. The broad visionary leadership has resulted in well-structured and coordinated research programmes with substantially increased external funding. They have developed existing talent very well. This creates a very attractive international environment for students and ensures the future vitality of the department. The unit has a longstanding and very successful engagement with MAXLAB and is well positioned to take on the leadership in the development of the Swedish synchrotron radiation research community. It is essential that the UoA maintains and further develops the instrumentation base at Electrum laboratory, including personnel, at the forefront. The integration of the Optics & Photonics UoA is challenging, but has the opportunity to be turned into a win-win situation for both UoAs. The unit has succeeded to transfer research results into spinoffs and, in the field of spintronics the unit has received an exceptional number of prizes. Members of the UoA are present in many internationally influential committees and are organizing successful international conferences. They are well present in the public media with their expertise regarding nuclear waste storage. The UoA provides a very attractive and stimulating international research environment, capable of attracting worldwide the best students and scientists in this field. Research co-operation with Swedish and foreign industry as well as research institutes is outstanding. They have a well-thought out recruitment strategy with a well-balanced age profile, and have taken excellent care promoting their young talents but should maximize their efforts to better equilibrate the gender balance.

Unit of assessment 4.4: Optics & Photonics

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

The scientific output of this unit is of high quality. Scientific papers are consistently of high quality, and the unit maintains an extremely high productivity, especially when measured against their small number of active researchers. This proves the overall excellent research quality of their permanent staff. Joint research with industry is at a very good international level and well recognized. The two most senior faculty members are world leading experts with a continuing high impact in their field of expertise including research policy via the European Technology Platform. The unit has established a strong link with Zhejiang University in China (JORCEP), one of the leading Chinese universities in engineering, and are continuously fostering this collaboration. However due to these external engagements, three out of four senior faculty members are only present part time at KTH, a situation which is not sustainable in the long run. External funding almost halved over the last four years and also halved is the number of researchers and PhD students. The recently introduced tuition fees for non-EU students has forced the UoA to leave the Erasmus Mundus MSc programme in photonics. The limited undergraduate teaching of the UoA further limits the funding and makes the unit less attractive for students. Fortunately, the technological and instrumentation infrastructure remains of the highest quality, recently supported by a sizeable grant for nano-photonics. The proposed move to materials physics is a logical and urgent organizational change to mitigate that the present status is subcritical. An additional way to improve this situation would be to establish a joint research programme with polymer research at KTH.

Expert panel 5: Energy Technology & Electrical Engineering



The units of assessment within the research field have profiles close to the KTH average. The unit of energy transformation stands out in terms of the larger number of impact publications per academic faculty. The share of external funding is double the KTH average for the unit of nuclear power safety, reactor physics & technology.

Unit of assessment 5.1: Nuclear Power Safety, Reactor Physics & Reactor Technology

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

The UoA has made significant progress with quality and quantity of the academic research and number of scientific publications. This may have in part resulted from the more favourable political atmosphere toward nuclear power in Sweden. Going forward with the Generation IV programme is essential, even though this activity is large and requires substantial focusing of resources as well as partnering across KTH, nationally and internationally. The UoA needs to consolidate its activities both at organizational and at the strategic level. The three divisions might benefit from merging into one, which would allow exploiting a closer collaboration on some topics such as safety, thermal hydraulics, modelling and experimental activities. The ELECTRA project has a high potential of impact both with the nuclear community and the society. The project is a 'high-risk, high-gain project'; furthermore, its success depends on political acceptance and decision. The UoA seems to be in some way isolated at KTH and a closer integration is recommended into the overall energy community for example through the KTH Energy Platform initiative. The number of peer-reviewed journal articles has increased in recent years, partly due to an increased number of permanent staff, and more than 90 percent of the articles are published in the most recognized journals in the nuclear community. Notwithstanding a strong link with the nuclear industry, mobility of research staff between academia and industry is limited. Personnel strategy includes hiring of tenure-track assistant professors in all research focus areas. The UoA needs to identify a clear leadership assuming responsibility for the future direction of the UoA, including a common vision for going forward and a suitable and cohesive organization of the unit. A long term strategy is possible and confirmed by a long term involvement in several EU Euratom and international programmes.

Unit of assessment 5.2: Electrical Power Engineering

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

This UoA is one of the largest electrical power engineering units within Europe. In many respects, the UoA is the most advanced one in its area in the Nordic countries. In addition to its consolidated close ties to the Swedish power industry, it has significantly increased its footprint at European level (via EIT KIC InnoEnergy key participation, FP7, standardization groups). The vision of the UoA is coherent with European roadmaps and the various research streams are consistent with that overall vision. The project portfolio includes visionary projects besides those that are more industrially driven, resulting in a significant impact on both industry and society. The traditionally strong links with industry do not impair the unit's academic performance which could be further enhanced by accomplishing more integrated and larger projects. Applied research should be maintained while strengthening the role of basic research and allowing research staff

to gain academic merits. The research profile is strong enough for KTH to brand itself as a leader in energy research. The project-orientated approach of the UoA has proven to be well-suited for assisting industry in shortening the time-to-market for innovations. The number of both peer-reviewed journal articles and conference articles has slightly declined in recent years, but the average field-normalized citation rate is on the increase. The impact and engagement of the UoA with society is extremely positive. Mobility between industry and academia is strong, and the UoA is deeply involved in academy-industry joint centres of excellence in power engineering. The UoA provides a very stimulating research environment, and is equipped with up-to-date facilities and with solid international connections. The unit maintains its sustainability through visionary leadership and by adequate investment in staff. For enabling a long term planning, the traditional collaboration framework with the Swedish power industry characteristic of the UoA is a particular strength. Overall, the UoA has shown a remarkable progress in recent years, including in terms of human resources strategy and leadership, and has further increased the research performance and international visibility.

Unit of assessment 5.3: Fusion & Space Plasma Physics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The UoA consists of two divisions focusing on space and fusion plasmas which both are dynamic and well-regarded in their fields. They have an enthusiastic research atmosphere and a healthy pride in their work and performance. Both divisions have good structuring and a clear vision of future actions. The plasma physics at KTH has a grand history starting from Nobel Prize winner Hannes Alfvén, who was one of the grandfathers of the field. Building on that expertise and experience, the UoA has moved forward with new avenues: The divisions are very aware of opportunities offered by upcoming space missions (especially those of European Space Agency ESA) or by the fusion research in the context of ITER and beyond (DEMO). Both groups are well established in the international arena in their respective fields holding major expertise and responsibilities in large international consortia. Furthermore, the groups are nationally well networked and have a clear sharing of research and technology development topics at the national level. The UoA as a whole has a clearly defined international reputation where they are making unique contributions that significantly advance the field. The instrument development and technological work is of very high quality, and the scientific methodologies used are sound combining well-defined experiments, analysis of experimental results and a variety of modelling methods. Societal impact is increased by doctoral theses made in collaboration with external organizations and a large number of publications with non-academic partners as well as reach-out activities to the public. This impact is further strengthened

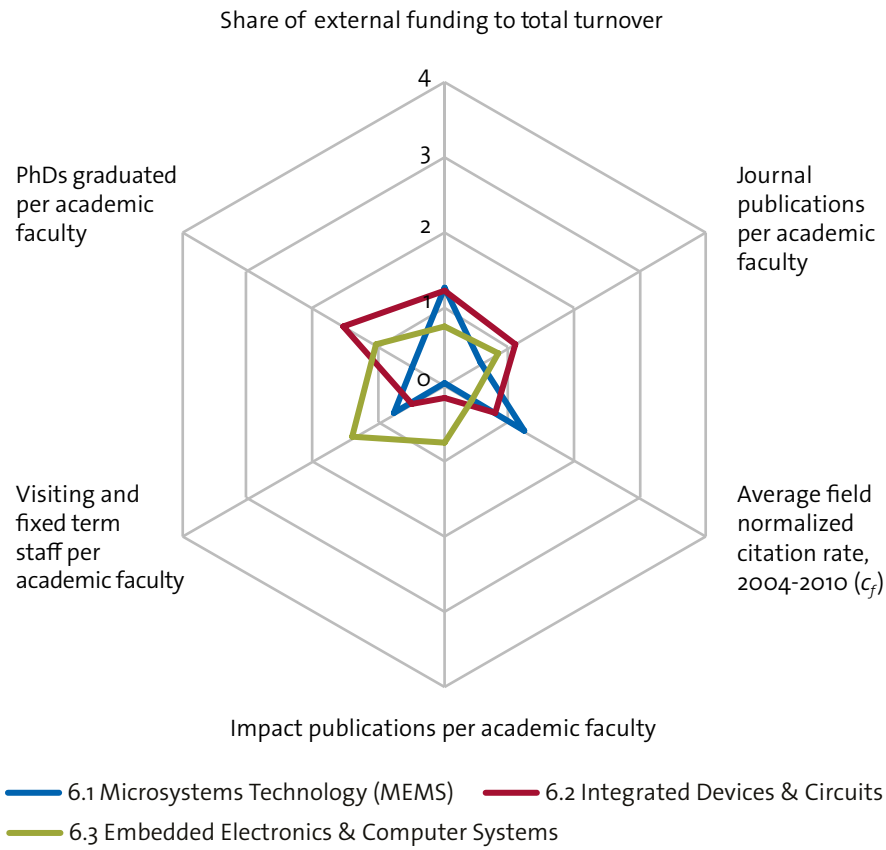
by research collaborations with external organizations. In particular the new business opportunities in the applied plasma groups deserve a top impact factor and also lead to good funding opportunities from industry. Internationally, the unit is very active, visible and possesses leadership positions in international organizations. The UoA has a very positive and enthusiastic atmosphere. It has acquired funding to recruit more graduate students, but mobility and renewal of research staff continues to be a challenge. Since both fusion and space plasma fields are heavily dependent on the evolution and future of large international programmes, it is important that the UoA positions itself clearly in the European roadmaps in a 10-year timescale.

Unit of assessment 5.4: Energy Transformation

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The UoA addresses two top subjects of today, namely climate change and energy analysis, and is thus well positioned to gain significant external funding in these areas. The traditional research areas in this UoA, heat and power and applied thermodynamics are in an equally healthy state. This has been reflected in a significant positive evolution of staff and funding growth and a healthy ratio of KTH versus external funding. The continuous growth has led to a large number of small projects; although consolidation, focusing and moving toward larger programmes is recommended. Enhanced collaboration with other groups, especially in electrical power engineering, would also be beneficial for the development of the research focus. Furthermore, new leadership has further increased the vitality to the programme. The UoA has taken the decision to investigate Smart Cities which is a topic that provides a lot of potential for the UoA; with integrated systems in e.g. buildings to be a possible focus in the future. The Energy Platform has served the graduate students and junior staff well for networking, but it might have further potential for impacting on the research in the future. As exemplified by the Smart Cities, the UoA responds very well to the emerging challenges and opportunities in the field. However, the rapid changing scene makes it difficult to develop a clear overarching scientific strategy. Here an effort should be made to develop a coherent longer-term vision; as the talent and funding base does exist. Staff structure is balanced, with several good young people on different levels of tenure track. Staffing strategy has been to hire PhD students after graduation without external post-doctoral periods: While post-doctoral stays abroad are recommended, they are not a requirement. There should be a stronger motivation for pursuing external post-doctoral career steps. The excellent research infrastructure has been recently renovated. Important aspects of the impacts of the UoA include enabling service access in remote areas and sustainable energy delivery. Staff are highly motivated and the atmosphere is forward-looking.

Expert panel 6: Electronics & Photonics



The units of assessment within the research field have a homogenous profile close to the KTH average. The flow of visiting faculty is particularly large in the KTH context for the unit of embedded electronics & computer systems.

Unit of assessment 6.1: Micro-electromechanical Systems (MEMS)

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The MEMS unit has expanded since 2008 through the hiring of four new members of junior staff. The quality and motivation of the newly hired faculty seem excellent. The number of PhD students has expanded although the number of actual PhDs

graduating through the assessment period is disappointing. It is expected that this will be overcome going forward through the graduation of the expanded numbers currently in post. The unit has focused on MEMS process development and targeted applications. This is closely linked to exploitation of the excellent facilities available at the Electrum laboratory for Si processing. Additionally they have developed MEMS specific process expertise centred on wafer to wafer layer transfer and polymers for micro-fluidics in general and biological application in particular. The latter is a new field that they have developed successfully in a short space of time. To date the unit has been focused on innovatively and imaginatively integrating new structures and phenomena developed/identified by others, within systems for particular applications. More research which is focused on exploring the 'bottom end' at the nanoscale would enhance the unit's activities. Particularly, the group should try to identify new phenomena themselves. The overall quality of the research presented is excellent in their respective fields. The research carried out by the unit is regularly reported in the leading international publications in the field. It clearly had international visibility and impact. The unit has been the source from which a significant number of new companies have originated. The tradition of spinning out companies based on research originating within the unit continues with some exciting prospects for the future. There is also a commendable record of patents which underpin future product development emanating from the unit. This is an increasingly competitive area with a rapid increase in new groups entering the field, especially in Asia. This necessitates strategic investment in longer term research goals, which should include physics and new materials, as well as technology. The panel suggests closer ties to industry. Towards that end, infrastructures such as maintaining an industrial advisory board, to provide future directions, in research and professional development would be encouraged.

Unit of assessment 6.2: Integrated Devices & Circuits

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The UoA has as its common denominator extensive use of the Electrum laboratory facility. In addition to leadership of some individual research themes, the unit provides coordination and support for a number of other activities centred around the Electrum facility. These include MEMS and Photonics work. The UoA attracts are large number of high quality PhD students from across the world. This is a major resource for the unit. The unit clearly has internationally leading expertise in the area of SiC based devices and circuits. It is arguably the strongest academic unit in the world. There is also exciting research underway in the area of Si nanoelectronics which covers both new structures and new materials. This has the potential to also develop into a world

leading activity. The quality of the research is excellent. The unit has had significant international impact in the areas of SiC and Si nanoelectronics. This is reflected through their high quality publications and participation in the organization of key conferences in the subject. In photonics, the recent collaboration with units in the US which has led to a publication in Nature Photonics is highly commendable. The unit also has had very significant impact with, for example, the spin-out formation of the new company TranSiC. Its acquisition after a relatively short time by Fairchild, a major semiconductor company, is a major achievement. The unit also has an impressive record of collaborating with industry through partnerships within EU projects. The unit should aim at higher impact and higher risk research which has the potential of yielding greater research rewards.

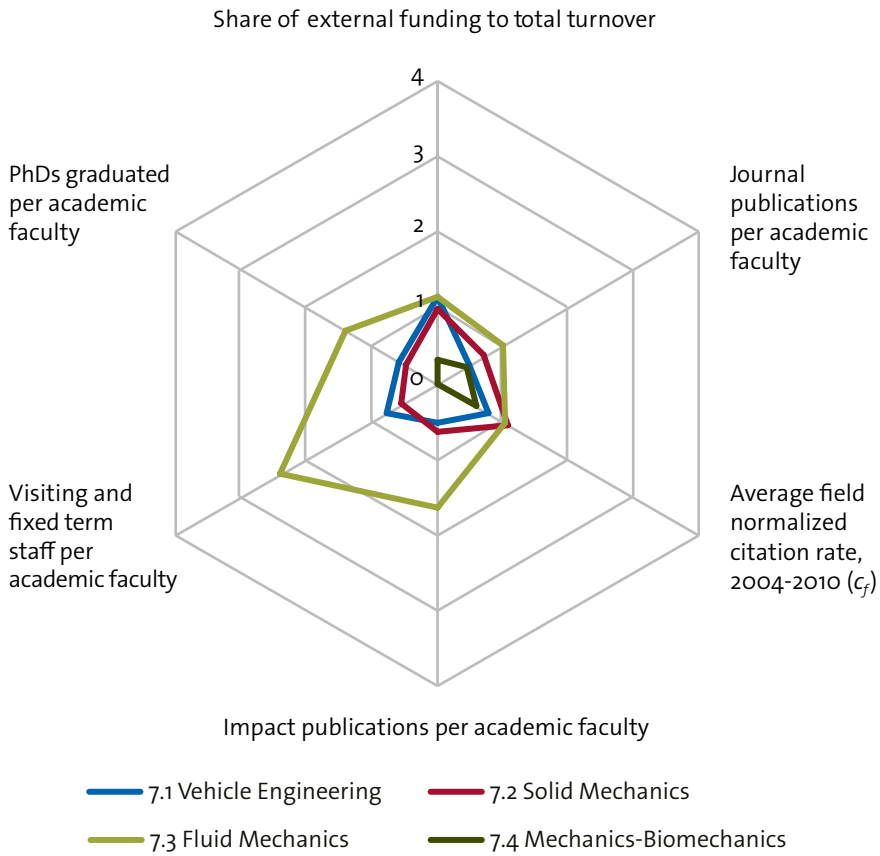
Unit of assessment 6.3: Electronic Systems

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

It is clear that there is great enthusiasm for research and engagement with wider society amongst many individual members of Staff. However, it was unclear where leadership responsibility lay and how as a unit there was overall guidance. The unit has had some reorganization in terms of faculty. The impression is that there is now no emphasis on integrated circuit design at the physical level in terms of research. The number of PhD students has expanded since 2008 and the number of actual PhDs graduating through the assessment period is satisfactory. Historically the unit has had high international visibility in integrated circuit design at the physical level. This expertise has now been largely directed at training and teaching at master's level. Currently there is emphasis on working at the higher system architecture level. This builds on the outstanding work within the unit on Networks on a Chip (NOC). However, clear distinction and international leadership in the area of system architecture is still to be established. Previous leading basic research on RF frontends has resulted in a good system-level design for remote-powered RFID tags. This, together with research on passives is now being directed at defining a new class of intelligent and functional packaging. This is an excellent example of how research can be transferred effectively to industry, in this case via the iPack centre. The quality of the research presented in Networks on Chip is excellent. The electronic systems for intelligent packaging research is clearly of national significance and has the scope for developing new and innovative products. Funding of research is raised mainly through projects. This leaves limited resources to diversify into new areas. The lead position the unit has established in training and education of SoC engineers in China reflects its high standing in the subject.

While the unit has output a significant quantity of publications there should perhaps be more focus on publishing in quality journal and leading international conferences. There is excellent engagement with the wider Swedish electronics industry which includes new smaller companies. Attention should be given to the longer term sustainability of the unit and its overall strategy. Short term funding requirements seem to be the overriding concern.

Expert panel 7: Applied Mechanics



The units of assessment within the research field perform close to the KTH average with the exception of the unit of fluid mechanics. That unit is much more outward orientated than the KTH average having a flow of visiting staff of more than double the KTH average.

Unit of assessment 7.1: Vehicle Engineering

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The group has a broad funding base, ranging from basic research funding (*Vetenskapsrådet*) to applied (SSF, Vinnova) and even directly from industry. The research within the UoA has clear relevance for many industrial sectors, which is demonstrated by numerous examples

of fruitful collaboration between the research groups and industry, with basic research being performed with focus on future applications. The group should focus on creating environments for long-term strategic research, simultaneously capable of being scientifically adventurous and transformative as well as being industrially and societally relevant. There are numerous examples of immediate and long lasting positive effects on company bottom line through products jointly developed with the industry. Also, the UoA has strong engagements in various centres of excellence for participating industrial and governmental organizations which have derived largely increased knowledge and skills to be used in future projects/activities. The extensive amount of external funding is another indication of external appreciation. The on-going interaction with the public society can be seen through participation in TV-programmes, open house events, public lectures etc. The lately established policy of giving academic merits for individuals temporarily moving into industrial positions will further strengthen the industrial impact and transfer knowledge back to the UoA. The UoA seeks to encourage collaborative research through a combination of theoretical, numerical and experimental modelling. The suite of numerical tools and hardware platforms is of the highest international standards. Equally, much of the laboratory infrastructure in acoustics, structures and aerodynamics will be the envy of any of the world's best groups. It is clear that the research environment is excellent. The future potential of this UoA will be excellent as long as there will remain a thriving vehicle industry in the country. It is clear that industrial partners value very highly the applied research output from the group as well as the doctoral graduates as excellent employees for their companies. The strengths of the group, particularly in acoustics and lightweight structures, must be retained and encouraged while simultaneously investing and improving the other units.

Unit of assessment 7.2: Solid Mechanics

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The UoA is consolidating and further developing its long established record of world-class excellence in solid mechanics, based on fruitful interaction between modelling, analysis and experiments. The classic strong areas of contact mechanics and fracture/material mechanics are now supplemented by biomechanics, with a focus on biological material characteristics; packaging technology and paper mechanics, and reliability of structures, integrating fatigue analysis and probabilistic evaluation methods. The new areas have increased the impetus of the classic subjects, and there has been an increased and successful emphasis on integrating high-level research and industrial applications. While the current research profile is fully satisfactory, there appears to be a need for the UoA to develop a procedure

for an on-going discussion and development of the research strategy, to identify new promising areas or new trends within the fields of research. Publications are highly cited, even when considering the higher average citation rates in Biomechanics. In summary, the research of the UoA demonstrates originality and is mostly internationally significant and with a high degree of rigour. Since 2008, the UoA has pursued a line of development with emphasis on active demonstration of the value/importance of the competence and research within the selected focus areas, and this policy has been very successful. This area has also led staff movements between academia and industry and shared research positions. The unit is well connected internationally, providing input on current research areas and topics, and also providing good channels for faculty visits and external placement of graduate students. The distribution of tasks deliberately makes room for younger faculty to acquire the qualifications necessary for promotion. Considerable foresight was demonstrated, when initiating the current areas in biomechanics and paper technology. However, the UoA does not at present appear to have a systematic procedure for continuous development of the research profile and strategy. The unit has established an excellent research environment that includes faculty, staff and students in a welcoming, positive and productive manner. Furthermore, a balance between experimental research and testing has been reached, whereby extensive facilities can be maintained in a self-supporting manner.

Unit of assessment 7.3: Fluid Mechanics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The UoA is building upon its long-lasting history of world-leading scientific excellence in the area of analysis and prediction of transitional and turbulent flows. This research even in the recent past has resulted in seminal fundamental findings and discoveries but also in break-through tools for the prediction of flow transition in aeronautics. The multi-disciplinary frameworks provided by the new cross-structure research centres the UoA is involved in, has been instrumental in preparing the UoA for future research directions, such as in combustion and multi-phase flows. The UoA is encouraged to enlarge its experimental component by hiring another professor in experimental fluid mechanics. The panel strongly recommends that the biomechanics component of the UoA join forces with its counterparts in the Mechanics-Biomechanics and Solid Mechanics UoAs to form a vibrant entity which is visible internationally and which leads to strongly collaborative research. The recruitment of truly international tenure-track assistant professors educated abroad should also be actively pursued in order to maintain intellectual and gender diversity.

The establishment of the Linné flow centre has led to the development of a large network of international collaborations. The international reputation of the UoA has further been enhanced by the organization of highly visible conferences, schools and workshops, and the award of a highly sought after European Research Council grant. The pre-eminence of the UoA in Swedish fluid mechanics has also been reinforced by the existence of the centre. The centre has served as a source of academic talent for private industry's needs in applied research, and its members have actively participated in the formulation of a policy in Applied Mechanics for national agencies. The group has clearly demonstrated the quality and relevance of fundamental research to practical problems, though the time scales for such applications are long-term. In spite of the diversity of topics within the UoA, there is a great unity and homogeneity in the research objectives and approaches. The leading international standing of the research programme has stimulated a steady inflow of talented graduate students from all over the world. The UoA should be particularly complimented for its highly successful policy of nurturing and channelling its most promising PhD graduates into permanent junior then senior faculty positions, although efforts aimed at addressing the gender imbalance should be actively pursued.

Unit of assessment 7.4: Mechanics-Biomechanics

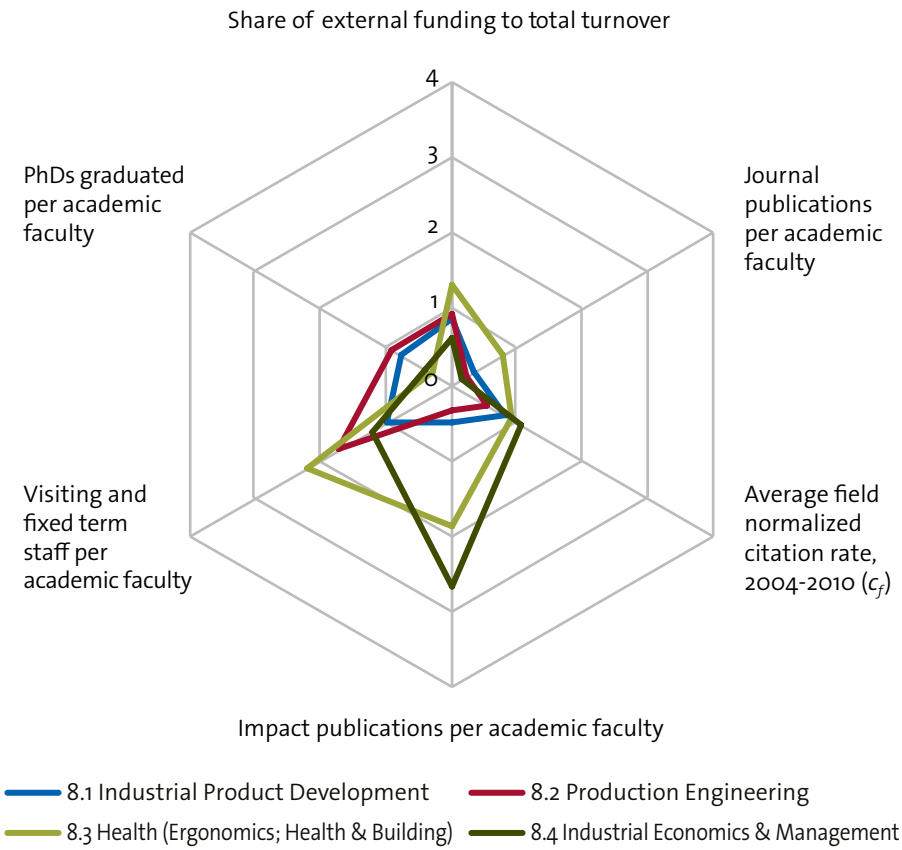
This unit demonstrated: research output quality that is recognized nationally for the majority of the UoA; considerable impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of nationally recognized quality for the majority of the UoA.

The output of the UoA is mixed, with the neuromuscular orthopaedics research being excellent, with a good degree of originality, internationally significant and with a high degree of rigour. The products of the space structures efforts are outstanding, and the results of the other activities in the UoA significant at the Swedish level, but not competitive internationally. The work on neuromuscular orthopaedics benefits from being a comprehensive integration of clinical and scientific work, with its leader being of central importance to addressing the challenges involved. The vision for this work is impressive and convincing and its organization well arranged. The other efforts on biomechanics and bioengineering are not of an equivalently high quality and are somewhat isolated activities. The research output on space- and deployable-structures is excellent, significant and rigorous, though not highly original; however this effort suffers from being isolated and sub-critical.

Nevertheless, this research activity is an important blend of design and structural mechanics. The output of research education degrees is high. However, the quality of the overall research output of the UoA is considered disappointing. The work on orthopaedics will have a significant impact on clinical practice at a time in the near future, and is already showing signs of providing some benefits in this regard and encompasses a high degree of engagement with society.

The sports science work connects the UoA with the Swedish Olympic organization and is a worthy activity having wider impact and societal engagement. The UoA has a reasonable stance in terms of the number of its doctoral students and the rate at which it produces finished PhDs, but it lacks post-doctoral associates and seems to be sub-critical in regard to extramural funding. Key strategic issues faced by the UoA have been defined and discussed in its planning statement only in a rather generic manner, without the specific circumstances of the unit brought into the argument.

Expert panel 8: Industrial Technology & Management



The units of assessment within the research field are rather varying in their profiles in relation to the KTH average. The flow of visiting staff is well above the average KTH level. The impact-orientated publication culture is more pronounced than the KTH average in industrial economics & management.

Unit of assessment 8.1: Industrial Product Development

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

The UoA covers research in four fields: integrated product development, system and component design, mechatronics and embedded systems, internal combustion engines. The research is predominantly application-orientated and of an incremental nature, rather than pursuing more disruptive ideas. Overall, the UoA shows good average performance. The research output through peer-reviewed international publications has markedly improved when compared with RAE2008 but for some divisions it is still to be enhanced. The UoA has a considerable impact on Swedish society by delivering well-educated masters and doctors to Swedish industry and by having close contact with a range of industrial partners. The UoA is advised to use their extensive external funding not in the first place for hardware or equipment investments (for educational and research purposes), but also to invest in human resources. The UoA should be more ambitious in the formulation of breaKTHrough topics and in playing actively their role as a system architect within KTH, as a catalyst to join forces and to create critical KTH mass for breaKTHrough systems development. More ambitious long-term integrated projects would be desirable. The recent appointment of a new professor in the mechatronics and embedded systems division was an important step towards an integrated view. Of note is the assistive haptic glove which stands out as an excellent example, beyond the state-of-the-art, of an integrated mechatronic system, with large potential in several application areas.

Unit of assessment 8.2: Production Engineering

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

Production engineering is one of the key technology areas of industrial orientated economies. This unit has a long tradition with scientific based contributions for the development of innovations in manufacturing like flexible manufacturing systems, structural change from mechanical to computerized production and manufacturing environments. New grand societal challenges like individualism, global networking in manufacturing and scientific based knowledge change the paradigms of future production. Production engineering is the enabling factor for adding value, competition and manufacturing of future products. Following the production challenges of the future, the unit has made remarkable progress, driven by a national initiative XPRES, which was initiated and driven by actors of the unit. XPRES is one source of scientific research topics in both basic research and application research. The unit developed a roadmap for research (for manufacturing 2020) and its main aspects include economic, ecologic and social efficiency, processing of new lightweight materials, high precision metrology, reconfigurable systems and digital production.

Regional networking is excellent and of extreme relevance for synergy effects between research and industries in the global economy. PhD students use industrial resources for their work and are supported and well managed by competent professors who have a high reputation in national industries. The unit can be ranked as one of the key actors in the European research programmes for factories of the future with excellent results particularly in adaptive systems and in high precision. They use the opportunity of European Research (7th FP) for their cooperation in Europe and cooperative research projects seems to be a very successful opportunity. Under aspects of future orientation, the research environment and especially the field of digital factories have to be added as a platform for multidisciplinary research. The unit plays a strong role in the universities ambitious strategy towards 2027.

Unit of assessment 8.3: Health (Ergonomics; Health & Building)

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; considerable impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of nationally recognized quality for the majority of the UoA.

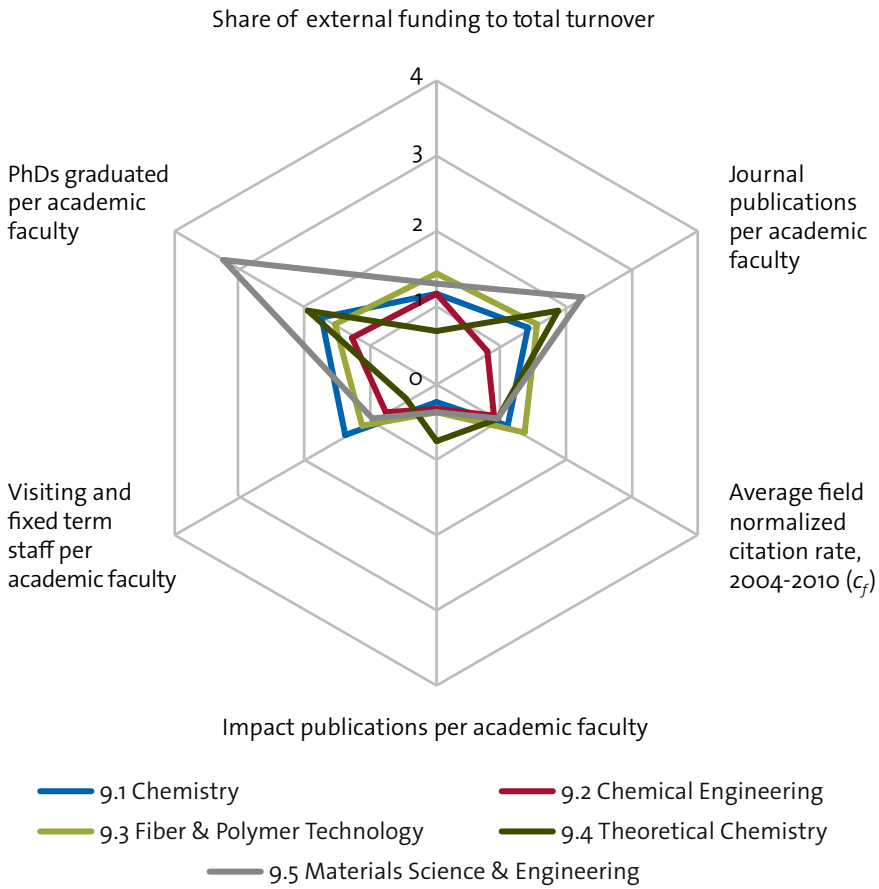
This unit has been seen at a time of transition. The panel believes that the quality is improving based on the findings of the previous RAE2008. This is to be applauded, as important and progressive research initiatives have been advanced. These initiatives reflect the need to address problems of great social relevance (e.g. ageing populations, patient safety, industrial performance and well-being of the workforce.) It is also important to recognise that the research within the institutional setting of health is of great importance for society. Recruitment of new staff has led to a welcome increase in high quality research output. If this progress is maintained we see no reason why this unit should not advance to the highest level of research quality. Some areas within the unit will need to be guided in this. The research environment requires further improvement and other units of assessment within KTH where better research support is available are urged to share their expertise with this UoA. The unit is constituted by four sub-groups: DASH (the Centre for Health and Building), ergonomics, lighting and patient safety. One of these groups is under establishment (patient safety) making it difficult to present an evidence-based assessment of the activities. However, the potential importance of this topic of research for society is acknowledged and the decision to initiate this activity applauded. Additional recruitment may need to be made to deliver a full systems approach to the complex applied research questions the unit seeks to address. Patient safety in particular is an expanding area of great social relevance. Careful selection of research topics will be required to prevent dilution of effort over too great a landscape of activity.

Unit of assessment 8.4: Industrial Economics & Management

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of nationally recognized quality for the majority of the UoA.

Industrial Economics & Management is an extremely popular subject of study in Sweden in general and at KTH in particular. This unit has taken the recommendations from RAE2008 seriously into consideration and accordingly, renewed their management, created a new strategy and recruited young, productive talents. Although research is a slow business, the results have started to show up. Quality and quantity of publications in international, peer reviewed journals has improved significantly without compromising the core competence of the unit, which is multidisciplinary, practice driven and industry relevant research. The UoA is recommended to implement its ambitious research agenda, and perhaps focus it even further from the current four-themed portfolio. The unit should also consider enhancing its cross-departmental collaboration within the school and also across different schools, in particular when it comes to entrepreneurship and sustainability challenges. There could also be space to extend collaboration and specialization between KTH INDEK and the business schools in the Stockholm area. The UoA can be congratulated on their choices. Technology driven, new high value-creating entrepreneurship and entrepreneurship are desperately needed for the renewal of high cost countries, including Sweden. The redistribution of labour over the globe, environmental challenges and stringent lead time requirements set enormous challenges for the needs of new scientific knowledge in operations management. Moreover, new ventures, knowledge intensive business and global business networks put pressure on leadership and work in the organizations of the future. This is the research portfolio that the leading peer universities are following. As the ambition level of the unit has increased drastically, it will encounter challenges to recruit top talents to fulfil its mission. These talents will also need proper induction and training in research methods and scientific writing.

Expert panel 9: Chemistry & Materials Science



The research profiles are similar for four of the five units of assessment within the research field. The levels generally stay just above the KTH average. The unit of materials science & engineering has a twice as high journal publication rate than the KTH average and three times the number of PhDs per academic faculty.

Unit of assessment 9.1: Chemistry

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The research performed in this unit is outstanding. It ranges from fundamental science to applications, and is highly acclaimed internationally. The research of the

UoA has a strong impact on industry, on governmental policy and is of considerable importance for the general public. It includes central fields of health – development of pharmaceuticals and biomedical materials; energy – development of future nuclear reactors, solar cells, batteries, and fuel cells, and environment – research on geological repositories for spent nuclear fuels, ecological chemistry for insect control, agriculture and forestry; lubrication and green corrosion protection systems. As an example of outreach towards the public, the unit has, in connection with the International Year of Chemistry, co-produced a popular science book that illustrates the importance of chemistry to society. The unit has consolidated into three divisions, organic chemistry, applied physical chemistry and surface and corrosion science, by merging seven former divisions. In addition, the unit hosts the Industrial NMR Centre and the Centre for Molecular Devices, which operate across divisional boundaries. The centres have many international collaborative projects with other leading groups. In general, the UoA has extensive collaboration with industry, including placement of graduate students in industry for part of their studies. It also excels in international academic collaboration, including exchange of faculty and students. Five faculty members participate in centres of excellence, one as coordinator and two as director. The research is impressive both in quality, diversity and breadth, ranging from advanced synthetic methodology to nuclear waste topics. Thus the potential for achieving future goals is high. Nevertheless some improvements are possible, including providing incentives and environments for enhancing internal collaboration within KTH, and ensuring that the present balance between basic and applied science remains. In addition, it appears that the current research topics are mostly promoted by professors or associate professors, and new research topics independently developed by young assistant professors are lacking.

Unit of assessment 9.2: Chemical Engineering

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

There was an enormous improvement in structure and performance of the unit compared to RAE2008. Not only are earlier problems with the staff age profile being solved, research activities are also much better focused. The unit now concentrates on energy and environment through high quality research on thermochemical, catalytic, and electrochemical processes for both energy conversion and environmental protection while developing pertinent investigations on other aspects of chemical engineering. The significance and rigour of the work done in the frame of nationwide and international collaboration with industry and research centres has resulted in an outstanding scientific and technical output. The activities of the UoA demonstrate a strong engagement to society, with a real impact, through modernization and improvement

of its education programmes at both MSc and PhD levels, and through its commitment to solving societal issues, especially within energy and environment, by using chemical engineering approaches and techniques. The research and educational environment of the unit within the School of Chemical Science and Engineering and the Green House Lab contributes to the success and visibility of the work accomplished. The lively, stimulating atmosphere in the research teams among both students and scientific staff was noteworthy. The large number of newly recruited faculty members with different expertise and background will make it possible for the unit to play a dominant role in the development of future Swedish energy systems. Fundamental research should be strengthened by increased collaboration with neighbouring KTH departments, e.g. Chemistry. It should be a goal to make basic research even more visible, for instance through mutual publications with partners from KTH and with external partners.

Unit of assessment 9.3: Fiber & Polymer Technology

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

Scientific achievement, in the form of scientific publications as well as general productivity and visibility of the unit, has been maintained at a very high level since the 2008 evaluation. After the merger of the two departments a steady increase in the number of publications has taken place. The quality of the papers has been maintained at a very high level and the normalized citation of the papers has increased gradually. Furthermore, the researchers of the unit have organized several important international conferences and the research staff members include four chief editors of highly ranked international journals. The research in the unit reflects important global challenges; it may enhance sustainable development and help satisfy important needs of society, in particular to the needs to increase use of renewable resources, to reduce polymer waste and to reduce the dependence on energy from fossil fuels. The UoA has developed a support programme for young faculty members, which is well regarded and highly appreciated. The high visibility of the UoA is reflected in good response to job openings. It is also worth noting that the instrument park is available to all its researchers. It consists at the moment of more than 150 pieces of equipment. The unit interacts with society in many ways, through various active engagements. The patent activity has remained at a relatively high level, although the evaluators had expected an even higher activity due to the high quality research performed in the department and the increased interest of industry in the research areas. Together with the well-balanced age profile of the scientific staff, the very high scientific competence creates an excellent and productive research environment.

Unit of assessment 9.4: Theoretical Chemistry

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The research of this UoA involves three steps: the development of new theories, their implementation into computer codes, and applications of these and existing methods to study chemical, biological and physical phenomena. The areas of application investigated by the unit are impressive. As already pointed in the 2008 assessment, the basic research in the Theoretical Chemistry UoA is at the forefront of international theoretical and computational research. The productivity in terms of published papers, graduated PhDs, and computer software is outstanding. The vision of the UoA, to use their ability in basic science, has led to DALTON, a computer package used internationally (more than 2,000 users). The package promotes the development of new scientific knowledge and of new methods in a dynamic interplay with experimentalists that create solutions to problems, at times of significant societal and technological value. The UoA, with its own scientific work and packages, thus has strong ties with a large number of international groups. There is considerable interest in work on real life applications like molecular electronics, photonics and magnetics. Similarly, atmospheric chemistry, nanoparticle technology, and biochemical and medically orientated problems, for example blood chemistry, are areas of interest in the UoA. Rare for a theoretical orientated unit, a US patent has been obtained. The unit is involved in many cooperative projects and the high quality of the unit has been illustrated by a number of prestigious awards, such as the Göran Gustafsson Prize in Chemistry from the Royal Swedish Academy of Science.

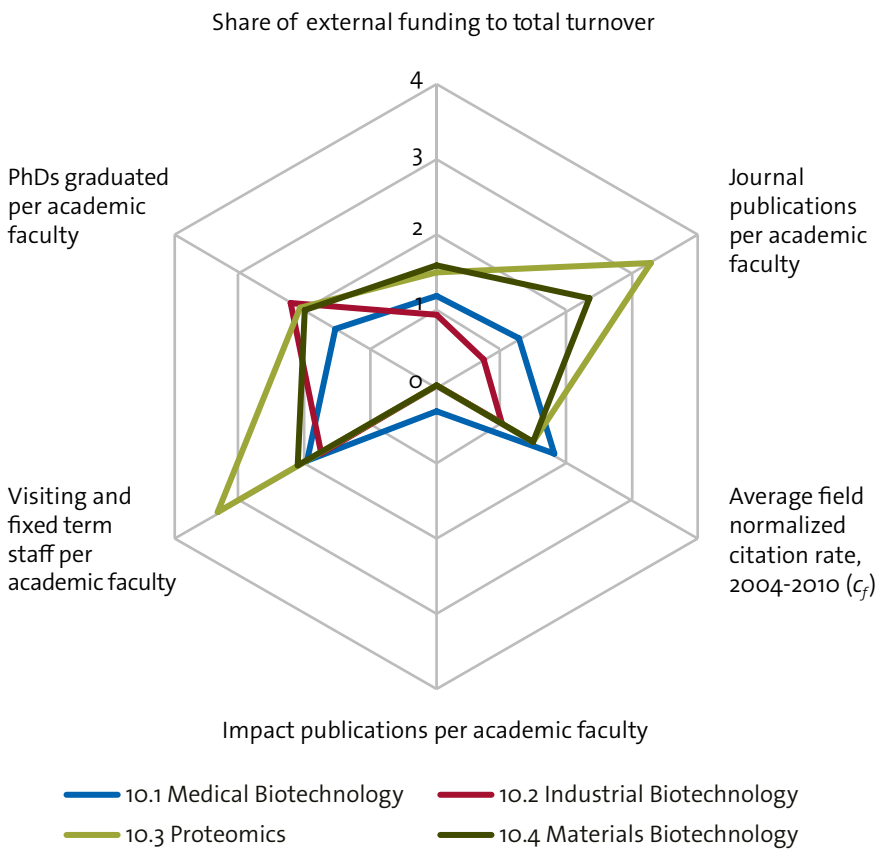
Unit of assessment 9.5: Materials Science & Engineering

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

This UoA is made up of three areas: materials function, design, and process design. It has a strong competence regarding modelling based on thermodynamics, kinetics and ab-initio calculations in combination with an experimental expertise regarding determination of thermo- physical and thermodynamic properties, measurements of physico-chemical phenomena in processes, as well as a range of advanced microscopy techniques. The quality of research in the UoA is of the highest international standard, both with regard to experimental research and to modelling in the extended range from atomic level to micro- and macro systems.

The work is continuously performed in several projects, platforms and spin-offs. Engagement with society has also been very active in this unit, including mobility between academia and industry. The doctoral education represents the ultimate top in the field, both in quality and with regard to the number of projects. The UoA has maintained a very strong collaboration with industries producing materials and applying different advanced materials in their products. The research activities are strongly international via joint projects, financing, exchange of researchers and publications. Finally, recruitment of new talent to eventually take over as and when the professors retire is not only a recommendation it is a necessary action.

Expert panel 10: Biotechnology



The profiles differ among the units of assessment within the research field. The performance in the research field is generally above the KTH average. The unit of proteomics is three times as publication-intensive as the KTH average and has a flow of visiting staff more than three times higher.

Unit of assessment 10.1: Medical Biotechnology

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

This unit of assessment is composed of two very different sub-units, molecular biotechnology and gene technology. The output of the two units is substantial and of high quality with many publications in the top journals and with high impact.

As the results of the molecular biotechnology group are very applied there is substantial commercial potential. The expertise of molecular biotechnology is based around affibody technology. Affibodies are small, highly specific affinity reagents that can be implemented against any target of interest. They have been integrated into a series of different applications starting from biosensing, to affinity purification procedures and in vitro diagnostics to recently in vivo diagnostics. The future path outlined is to use the characteristics of affibodies to move into therapeutics. Since the last assessment the sub-unit has seen the addition of a young full professor with expertise in the more chemical aspects of protein engineering and this recruitment complements the molecular biotechnology department perfectly on its quest towards the application of affibodies for therapeutics. An absolute highlight of this department and this unit is the impressive development of in vivo diagnostics using the isotope labelled affibodies. This is now being exploited with a commercial partner. The second sub-unit is the gene technology department that in the past has been focusing on DNA technology development and its application. With the creation of the Science for Life Laboratory, this entity has moved to a new site and taken on the responsibility for running the high-throughput DNA sequencing facility. The last couple of years have been devoted to getting this operation up and running and developing powerful data analysis pipelines. The platform supports many collaborative projects. Highlight projects are the de novo sequencing of the Norwegian Spruce and the microbiome scan of the Baltic Sea. Both projects are technically demanding and mastered well by the department. Equipment-wise this unit of assessment is in an excellent position. However, it needs to be kept in mind that the generation-time of hardware in this area can be very short and in order to say on top might require substantial investment.

Unit of assessment 10.2: Industrial Biotechnology

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The research within this UoA covers several areas, with biocatalysis being the most important one. Here the research has to be ranked within the top ten groups worldwide. This holds in particular for the area of enzyme promiscuity where this laboratory was among the first to establish this novel topic some years ago by contributions of high originality and significance by clarification of the underlying mechanisms. Also the scientific output can be characterized having high rigour both regarding definition of the purpose for performing the investigations and in applying the appropriate methodology. However regarding the recent scientific output it has to be mentioned that, in at least one case, more emphasis has been given to performing a high teaching load.

In total, the UoA is in a good to excellent shape, having highly qualified personnel performing research of high quality which is well recognized internationally. Without doubt the UoA is on a good course for continuing the positive development. Not only within the major area of biocatalysis which is in particular acknowledged worldwide, but also regarding the other research activities. A well experienced staff takes care to provide good progress in several areas. Special concerns are to provide developments of relevance for industrial application, and also to take care of sustainable developments, as well as to improve the methodology. This holds in particular for biorefinery by using sources from nature and waste as the basis of an approach to useful products replacing those from oil origin. An extension of cooperation within KTH is recommended for this unit where an optimization would bring much benefit with respect to exchange of experience and enlargement of the critical mass.

Unit of assessment 10.3: Proteomics

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The proteomics UoA consists of the divisions of proteomics and nanobiotechnology. Both are very large research projects. A publicly available Human Protein Atlas is produced by this unit with a goal to develop specific affinity reagents to map all human proteins in healthy and diseased tissue, so providing a very valuable tool and resource for biomarker discovery and human disease understanding. The main medium term objective for the Human Protein Atlas effort is to launch a first draft of the human proteome by the end of 2015 covering most of the protein-coding genes. The unit has very clear objectives, such as to work on new features to improve the quality and completeness of the database during this period, such as a dedicated subcellular atlas, a rodent brain atlas, complementary expression data based on mRNA transcript characterized by deep sequencing using next generation sequencing, complementary data from GFP subcellular probing together with the Max Planck Institute, epitope mapping efforts, introduction of recombinant binders as a complement to the antibodies, complementary analysis with mass spectrometry and functional biology (including whole genome screens) and more efforts to elucidate the different isoforms generated from many protein-coding genes. The long-term objective is to generate a high-quality atlas in 2020 with highly validated data annotated in a precise manner using various efforts. The UoA is also heavily involved in the new effort Science for Life Laboratory, which is a centre for high-throughput biology based on genomics, proteomics, bio-imaging, functional biology, and bioinformatics and systems biology. This new centre, with a UoA professor as the director, is a joint effort between three universities in Stockholm: KTH, Karolinska Institutet and Stockholm University, with KTH as the formally responsible partner. The second big effort is a recently formed Swedish-Danish consortium which,

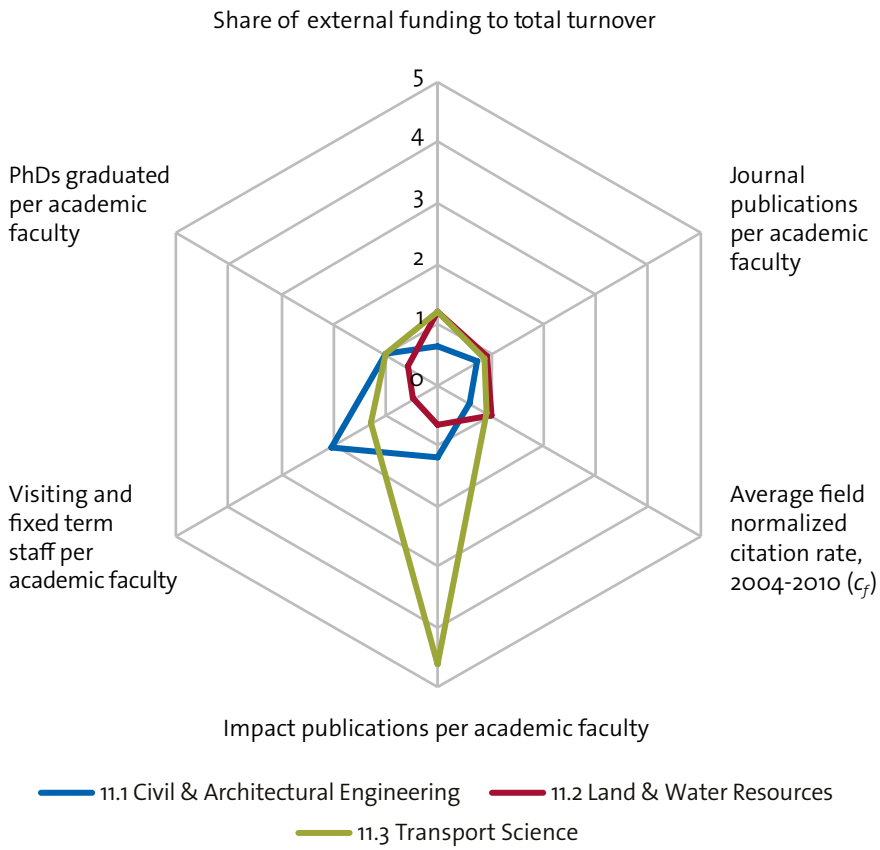
by the use of metabolic engineering, aims to develop micro-organisms tailored for production of fine chemicals or high-energy compounds. Altogether, the research environment for the unit has been built to fulfil the high standard requirements this kind of research demands. International mobility should be further encouraged, both from the incoming and outgoing side. The dependence of the major funding from a few single sources is a risk and, obviously, the securing the Protein Atlas project as a resource beyond 2015 is an issue of major concern to KTH and to Sweden.

Unit of assessment 10.4: Materials Biotechnology

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; considerable impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The orientation of this UoA in materials biotechnology is innovative and of high strategic relevance. The unit combines fundamental research of the highest quality (into the mechanisms of synthesis of cell wall polysaccharides) with use of newly discovered and characterized enzymes for the production of novel polysaccharides with new functionalities. The significance of the research has been recognized by the support of activities in four research centres, two of which are directed by scientists in this unit. Despite the strong foundations in fundamental research, and the effective translation of this fundamental knowledge into new materials of industrial potential, recognized by the foundation of a spin-out company and significant investment from companies both national and international, the UoA is at significant risk, because key personnel have been recruited by competing institutions without replacements being promised by KTH. The current very remarkable achievements are the result of the efforts of the professors over the reporting period: for example, four centres of excellence, a spin-out company, and an impressive external funding portfolio. The potential for the UoA in the future is enormous. The ability to produce new materials with innovative functionalities from wood is really exciting. The UoA would benefit greatly from closer collaboration with specialists in applications who can advise them on the type of innovative materials that different industries need, and the specifications that such materials need to meet and the economic considerations. The sustainability of the excellent research environment of the unit is questionable as a result of the lack of investment in new appointments to the division.

Expert panel 11: Technology for the Built Environment



The profiles of the units of assessment within the research field differ considerably especially in outward orientated activities. The profile of the unit of transport science is five times higher for impact publications than the KTH average. The flow of visiting staff is double the KTH average for Civil & Architectural Engineering.

Unit of assessment 11.1: Civil & Architectural Engineering

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

In general, the quality of basic and applied research at the Civil & Architectural Engineering unit of assessment is recognized internationally.

The UoA has important roles in proposing innovative and efficient solutions for the built environment and for the management of civil infrastructure systems. For the successful future of the UoA, priorities should include close research interactions among the members of the UoA; and collaborations with the national and international construction industry, building owners and authorities, and top researchers in sustainability, reliability, infrastructure maintenance and management, life cycle cost of civil infrastructure, and optimization. The panel recommends the establishment of a research centre for green, smart, economical buildings and transportation infrastructure to establish necessary collaborations and provide access to laboratory facilities. Other recommended facility enhancements include updating and enlarging the material and structural laboratory and establishing at least one experimental facility to demonstrate innovative materials and building technologies under real-world conditions.

Unit of assessment 11.2: Land & Water Resources Engineering

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; considerable impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

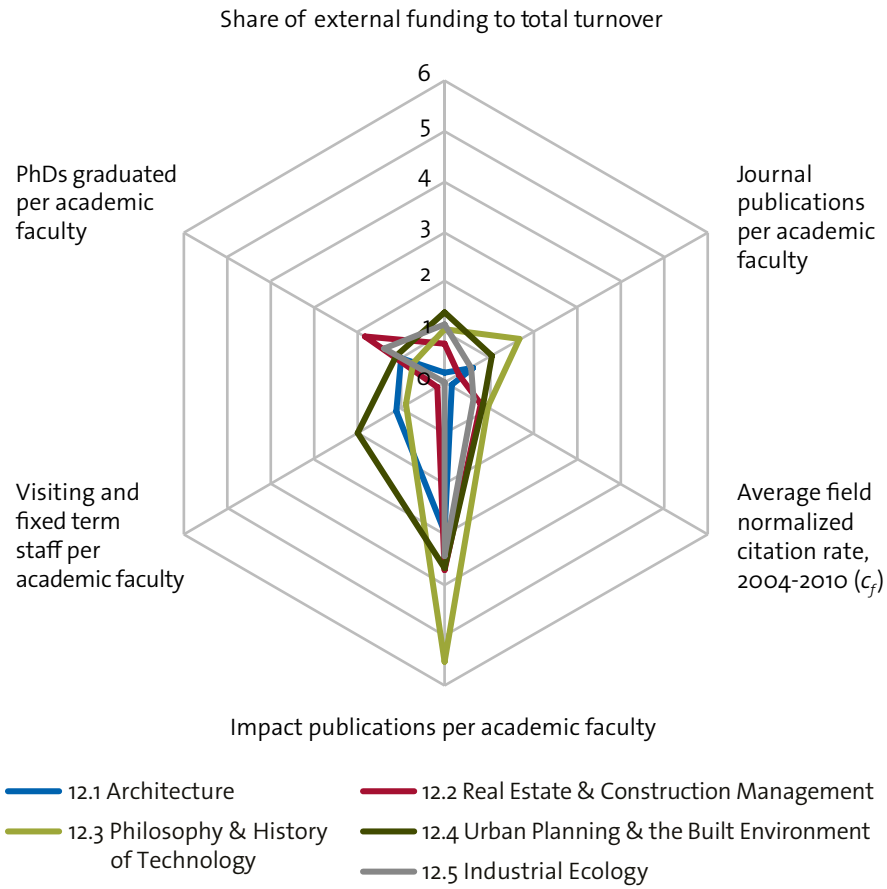
The unit of Land & Water Resources Engineering is comprised of researchers with diverse research foci, disciplinary backgrounds, and size of programmes. Such diversity is to be expected for a broad, multi-faceted programme in natural resources engineering and management, with implications toward sustainable use of freshwater, energy, and land resources. There appears to have been variable progress towards finding a consensus path towards convergence in research programmes within the unit, both in terms of guiding principles for scholarly activities and engagement with various partners. The unit has some strong programmes, but there has been variable success of development of fully functional linkages across the research clusters. However, UoA faculty and staff are fully aware of the need to make further progress, and have had active discussions about the need for change (e.g., adoption of engineering systems approaches to achieve synergy and integration). Information provided to the review panel suggests that integrated research projects could be successful (e.g., GESP) and have considerable impact; similar efforts to engage with others are underway (KILV and BONUS); such efforts should be strongly supported and encouraged. The unit needs to better integrate, articulate and promote not only the scientific achievements, but also the societal relevance of their research programmes such as negative consequences of intensification of natural resource extraction and consumption. Establishing a centre would help in this regard. The UoA is doing some good quality research and outreach, but with improvements in organization, better integration of research across clusters and more proactive outreach, the research could be more effectively integrated resulting in greater impact and success.

Unit of assessment 11.3: Transport Science

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

The quality of basic and applied research at the transport science UoA has achieved a world-leading standard that includes all three major criteria: research output, impact and engagement with society, and the research environment. This assessment is based on wide-ranging information which included faculty presentations, questions and answers, interaction with graduation students, laboratory visits and the assessment information provided by KTH on unit productivity. The faculty, staff and students of the unit work hard to collaborate and integrate their work as a research team to address overarching research questions. The synergies of this approach were evident. Transport Science performs both basic and applied research that reflects a balanced view of needed research. The research process typically includes international collaboration and aligns well with EU funding programmes. The results of research by the UoA clearly have an impact on the international transportation research and management communities. The Centre for Transport Studies (CTS) demonstrates an outstanding understanding of policy and decision processes. Research results within Traffic and Logistics are potentially paradigm shifting. The same can be stated for work within the Centres and specifically so for Road2Science. Risks to this high performing unit, however, include loss of key faculty and/or a major funding decrease. The level of funding, which includes initiatives such as TRENoP, should be continued by the Swedish government. It is this type of funding that will keep the Transport Science unit operating at a level necessary to sustain their high quality research and outreach programmes.

Expert panel 12: Architecture & the Built Environment



The research profiles among the units of assessent within the research field differ markedly in relation to the KTH average. The number of impact publications per academic faculty is three to five times as high as the KTH average. The unit of philosophy & history of technology at the same time has a publication-intensity close to double the KTH level.

Unit of assessment 12.1: Architecture

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA. There have been notable improvements in the quality and visibility of research

produced in the UoA since the last RAE assessment in 2008. Since that date, a variety of areas and platforms for research have been established. The last four-year period has also seen a significant amount of hiring of strong faculty staff and doctoral students. The UoA has also managed to build up a number of collaborations with other Swedish schools of architecture, as well as with several major international universities. The multiple-university research network set up with the three other Swedish schools of architecture is now bringing in a substantial amount of Swedish research council income. There are currently also important link-ups internally within the School of Architecture & the Built Environment and also with other departments at KTH. Notable research work has been produced; in particular, the work of the space syntax design group and the architectural history and theory group in relation to welfare state architecture and to feminist critique has become internationally renowned and is of extremely high quality. A number of significant publications have already come out of these research initiatives. An ambitious programme of bringing in internationally acknowledged scholars to give lectures and seminars has helped to add to the lively intellectual atmosphere. The faculty staff and students have been also actively participating in international conferences as panelists and moderators. In terms of engagement of the UoA with the world outside academia, several research outputs have had significant social impact. All in all, within only a few years, the increase in both the quality of output and intensity of the research activity has been remarkable. However, it is important to note that many of the research initiatives in the UoA are still at a relatively early stage and would clearly benefit from a more focused and structured research vision. A clearer strategy in terms of hierarchy of research topics and prioritizing aims and objectives would enable the UoA to define its short-, medium- and long-term goals.

Unit of assessment 12.2: Real Estate & Construction Management

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

This UoA is a combination of four academic divisions: two well-established and well-known groups of real estate researchers – one in building and real estate economics, the other in real estate planning and land law; and two units seldom to be found alongside real estate units: CEFIN (a banking and insurance research centre whose research is grounded largely in business administration), and 'construction communication'. The two latter groups have a shorter research history. Although there is no compelling academic reason why these four programmes should be grouped together, they have managed to conduct a higher degree of cooperation than one would have expected. The CEFIN centre is the only division whose activities and budgets are mostly research orientated.

The other divisions have major teaching obligations and the proportion of their budget from research is rather low. There is clearly a strong research culture within the UoA and evidence of high quality outputs. Particularly impressive was the engagement of the unit with market participants, policy makers and the wider society. Research outputs were, not unexpectedly, of mixed quality, but overall were good or very good. However, there is scope for improvement. In some of the divisions there is insufficient willingness to take structured, coordinated steps towards increasing the research budgets. Whilst there was a commitment to supporting individual researchers and collaborative research projects, the UoA needs to develop a clear vision for the future and a clear strategy for its achievement. To strengthen its international profile, the UoA should consider recruiting international researchers to support both the newer research areas as well as to strengthen the better-established expertise.

Unit of assessment 12.3: Philosophy & History of Technology

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

By any measure, this is a remarkable unit of assessment. The unit conducts first-rate research and has a strong and supportive research environment. Unit members display a well-deserved, quiet confidence and have been very successful in gaining grant support. They have also become advisors to government and have been prominent in the media. Both Philosophy & History of Technology were well reviewed in 2008, and both have improved since that time. The philosophy group has become a leading player in the philosophy of risk and in belief revision, with widely cited publications. They have developed new approaches in these fields, connecting them to engineering disciplines (philosophy of risk) and to computer science (belief revision). They have published in the best journals in these fields and they have been successful in addressing a variety of academic audiences. Likewise, the history of technology group has published fine articles in leading journals. In addition, they have made many contributions to books and also written full-length books, in both Swedish and English. Both groups show real originality in their work. The divisions have shown that they are able to do both more fundamental work in their disciplines and more applied interdisciplinary work, showing that they have been able to manage this delicate balance. This is an asset that should be cherished in the future. Each of these divisions would increase their visibility if they held more international events in their fields, such as conferences and seminars. They have done this to some extent, but given their high position in their respective fields, there is an excellent chance to gain more recognition and increase their attractiveness to international partners. Both divisions need to develop a long-term strategy for how to maintain this very high level of performance in the light of the problem of the medium-term succession of several of their key leaders.

Unit of assessment 12.4: Urban Planning & the Built Environment

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of world-leading quality for the majority of the UoA.

This UoA covers a very broad range of research, has grown substantially in the last four years and is performing as a whole at a significantly higher level than in the 2008 RAE. One of the main reasons for this is undoubtedly the high quality of academic leadership for the UoA itself and for its constituent groups. This is very impressive and a model for planning schools across the world. There are good opportunities to strengthen the already excellent work on sustainability in KTH by bringing together the industrial ecology and environmental strategies groups, although the impact of such a transfer on the research future of the industrial ecology group should be carefully assessed. The unit has an enterprising and innovative approach to research funding and to attracting the best talent at both senior and junior levels. New recruits are of a high calibre. The UoA is also very successful in recruiting good home and international PhD students. This UoA is outward-facing, enterprising and makes the most of any appropriate opportunities that present themselves. It acts strategically and cohesively. This is a UoA that regards impact as an absolutely crucial aspect of its mission. This is true both in terms of impact on Swedish society and in relation to international issues. The UoA is clearly doing everything it can to maximise its impact on society and is ready to respond to new opportunities to extend this further. For instance, geoid modelling and cooperation with Lantmäteriet (the Swedish authority for mapping, cadastral and land registration) and other mapping organizations in Sweden, and also internationally, is a very important feature of engagement with society.

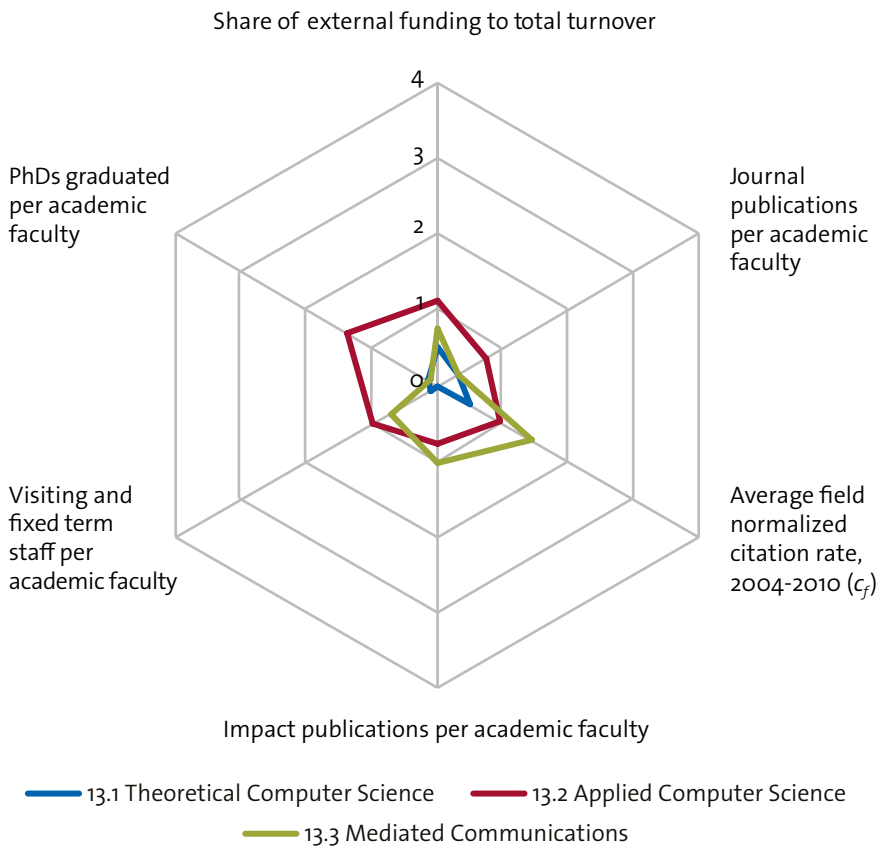
Unit of assessment 12.5: Industrial Ecology

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research of internationally recognized quality for the majority of the UoA.

There is evidence of increasing productivity in this unit in terms of published peer-reviewed papers over the past four years. Work over the period has focused on quantitative approaches to urban metabolism, taking account of social and economic contexts. However, the unit has not been able to recruit social scientists, as was recommended in RAE2008, and has also experienced difficulty in finding and collaborating with social scientists within KTH. Their principal collaborations are with practitioners outside KTH, within the Stockholm region and in Asia, with growing links with China.

The unit has a respectable and growing rate of output in international peer-reviewed journals with varying focus and quality. There is a deep commitment to working with practitioners, and a number of long-term relationships with research users which have led both to the application of research and the development of its research agenda. The structure, coherence and enthusiasm of the unit are commendable and help create a supportive environment for research students. Despite the range of topics being worked on, the unit appears to be a cohesive group. The combination of environmental systems thinking with a focus on urban systems in the context of social and economic change is a very promising and timely multidisciplinary research field. There is a great potential for more effective and productive collaboration across KTH in this field. However, as long as the unit remains at its present resource level and continues to be isolated within KTH, there seems little prospect that its range and status can develop further.

Expert panel 13: Computer Science & Mediated Communications



The profiles of the units of assessment within the research field differ markedly but in general stay close to or below the KTH average. The unit of mediated communications has a low level of publication-intensity and a high level of field normalized citation scores in relation to the KTH average. The profile of the unit of theoretical computer science resembles the profiles in the research field of mathematics.

Unit of assessment 13.1: Theoretical Computer Science

This unit demonstrated: research output quality that is internationally excellent, but which falls short of the highest standards of excellence for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The unit has recently been formed in its current composition. The UoA does not have a formal group structure. The work is clustered around several key persons, is of very high quality overall, and covers many areas such as complexity theory and approximation algorithms, security and formal methods, cryptography, privacy, model based testing, natural language and education, databases, and modelling large systems. However, there are various other activities in the unit where the research output does not reach the same very high standard and interaction between groups in this UoA is not necessarily strong. The majority of the work belongs to theoretical computer science, the work on natural language processing being the main exception. The societal impact of the UoA is strong via some innovative and widely used applications of computing theory. The recently recruited young professors are very promising in their research. The unit has chosen security as a high impact application area and is in the process of strengthening its expertise in security. For a theory unit, this development policy is well-justified and has potential of developing the UoA into an internationally very strong, leading centre in the security-privacy area. Engagement with society has arisen through several contributions to e-voting projects, through the provision of widely used arithmetic software, and through teaching courses on IT security. The two software programs are outstanding examples of the real applications of computing theory. Mobility of the researchers and dissemination of research is on decent level, and the unit is actively participating in several research centres at KTH that have substantial industrial involvement. For a theory group the practical impact is outstanding. Progress on SAT solvers enables research in many other areas. The unit has been able to attract excellent young people to its postdoctoral and tenure track positions, and it has a simple but appropriate development strategy to recruit and build on the very best, talented people.

Unit of assessment 13.2: Applied Computer Science

This unit demonstrated: research output quality that is world-leading for the majority of the UoA; impact and engagement with society that is somewhat above 'considerable' (but not deemed 'outstanding') for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The unit spans a wide array of research topics: computational biology with emphasis on computational neuroscience; robotics with an emphasis on grasping combining vision and touch; music and computation in order to understand musical expression and sound, so-called sonification, for augmenting visualization or real-time feedback in sports training;

integrating speech technologies with dialogue models to realize natural communication for more realistic interaction with computers, avatars and robot heads. In all areas the unit exhibits excellence, and there is evidence of original research in all fields, with quality scorings that are internationally excellent and world-leading for a substantial part, if not the majority of the UoA. Research output is internationally excellent in all fields, with a substantial number of units reaching the level of world-leading quality. This is particularly true for the neuroscience groups and several of the robotics groups. This overall judgment is also based on the high number of EU projects acquired by the UoA. The chosen topics are very well aligned to have high impact on societal needs and engagement with society is truly outstanding. Many of the projects are of high potential for improving the quality of life for people with various disabilities, improving performance in various human activities, enhancing the array of educational tools. Further down the road one can expect impact in the medical field. There is evidence for numerous interactions with industry and the creation of spinoff companies. Very high impact on e-inclusion, e-health and museum exhibits. The proximity to the life sciences clearly is of benefit to the computational biology group. Nonetheless it seems that the unit as a whole is spread out over a number of locations making on-going daily interactions more difficult. The unit as a whole can achieve world leadership if it can develop the already significant interaction and integration between the different research projects even further and, in particular, if more work can be focused around methodological tools that are employed in all the groups.

Unit of assessment 13.3: Media and Interaction Design

This unit demonstrated: research output quality that is recognized internationally for the majority of the UoA; outstanding impact and engagement with society for the majority of the UoA; and a research environment that is conducive to producing research quality somewhat above 'internationally recognized' (but not 'world leading') for the majority of the UoA.

The work that is being carried out in this UoA, media and interaction design, could have high societal value; the researchers have chosen good topic areas. These areas are likely to become central in the future, they are a good bet and we feel it is important to have these topic areas of research at KTH. The work at the unit has the potential to complement more technical areas at KTH by bringing in the social sciences, arts and humanities, all of which we see as positive and definitely a global trend. Clearly the unit can attract many potential faculty and student candidates and is in demand, as evidenced by attracting great talent recently. There is also a good gender balance of the faculty and students. The unit is very interdisciplinary but this also creates big challenges which can also lead to problems. While is important that there is a unit that brings these research ideas and courses to the school, care must be taken in terms of an overabundance of 'one off' projects with no real systematicity. There was a perceived lack of rigour/depth in the methodologies being used.

Lack of methodology leads to a lack of clarity and communication problems. Much of the faculty seems to be new to the unit so perhaps the group has not yet settled into a comfortable, efficient research routine. This can be further evidenced by the low number of publications, for instance. There is good collaboration within and external to KTH amongst the faculty and students, and obviously the researchers are well networked and politically aware.

This bodes well for the beginnings of a deep research entrenchment in many facets important to the future of society. The unit is doing exceedingly well with impact and engagement with society. There is a clear emphasis on having a large impact on society, and accessible design for all. There is a keen amount of energy around the medical domain, energy companies, education and sustainable computing. As stated in the introduction, these domains are critical for the future and it is very good that KTH has such great momentum here. There is also good participation at the government and industrial levels. Again, we feel that this is not only being carried out at a good pace now, but that it will likely accelerate as the new faculty get situated and collaborations begin to grow.

CHAPTER 6. SUMMARY AND CONCLUDING REMARKS

Similar to the 2008 exercise, RAE2012 was designed as a strategic process that would engage the entire staff of KTH. The considerable effort faculty and staff put into preparing and completing the evaluation packages, as well as hosting the site visits, represents a substantial investment from all of KTH in this process. One conclusion from RAE2008 was that the definition of research excellence and the linked choice of assessment dimensions needed further development.

Excellence in research means that the quality of the research is recognized by international peers in terms of originality, significance and rigour. This is the academic footprint dimension of KTH research. But excellence in research also means that the research is recognized by the same international peers as having an impact on societal and economic development. This is the societal and economic footprint dimension of KTH research. Hence, the three broader categories of research output quality, impact and engagement with society, and research environment were chosen as basic dimensions of evaluation in RAE2012.

The fact that RAE2012 addresses the current international and national discussion about the need to focus on research impacts and increase the engagement with business and government agencies does not mean that the importance of excellence in basic research is played down. Rather, it means that it is important to broaden and make more systematic the values produced by university research in its context of education and industrial and societal outreach.

As a result of the 2008 exercise, KTH gained an understanding of the strengths and weaknesses of its research base, which led to concrete actions to strengthen KTH. A general conclusion from the activities undertaken as a direct or indirect result of RAE2008 is that the investment in research assessment has paid off. RAE2008 created a new focus on the importance for KTH to monitor its research performance and to introduce mechanisms to promote internal coordination of both research management and strategy. The most important recommendation from RAE2008 was to renew faculty as a strategy for long-term excellence in research.

These key findings were also reverberated in the RAE2012 peer review results by the expert panels. The observations and insight into the KTH research base included the identification of a number of strategic and structural strengths at the university level, as well as some weaknesses. The general strength of KTH is highlighted by the fact that nearly half (22 of 47) of all units of assessment were found to have research output quality deemed 'world-leading for the majority of the unit'.

This reaffirms that KTH continues to have a strong, internationally competitive research base that successfully combines innovative and curiosity-driven research, new fields and interdisciplinary work.

More than half the units (24 of 47) were assessed as having 'outstanding impact and engagement with society for the majority of the unit'. The types and levels of industrial relations and entrepreneurial activities revealed by RAE2012 confirm that research carried out at KTH continues to be taken forward effectively and to the benefit of society. Engagement with society, including industry, companies and other government agencies was found to be strong and vital, with a growing number of research centres and contracts with industrial partners over the period 2008-2011, as well as many papers co-published with industry, as well as a growing number of industrial doctoral students and adjunct professors. KTH continues to have a good innovation performance with many successful patents and some fast-growing and highly profitable spin-off and start-up companies. The increased focus for supporting patenting and technology transfer, developed over the last four years, promises to lead to a sustainable and vital innovation footprint from the KTH research base.

Around one-third of the units (16 of 47) were assessed as having the vital and sustainable environment conducive to producing research of world-leading quality for the majority of the unit. Units with the best performance have a good balance between producing quality research with high impact on society and a healthy age and competence profile with both established and young faculty, as well as high quality sustainable research infrastructure and facilities.

The bibliometric analysis confirmed the excellent performance of those research areas which have a strong tradition in publishing in peer reviewed international journals. The results also showed an overall increase in average citation rate for KTH researchers, with the average field normalized non-fractionalized citation rate (c_f) having risen from 1.18 to 1.42 between 2004 and 2010[12]. This indicates that the gains observed in c_f were offset by an increase in the number of authors for each article. The bibliometric analysis also highlighted the importance of supporting and developing more top researchers at KTH to lift the overall research output intensity for KTH, as well as the importance of co-publishing with other researchers outside KTH. As expected the publication cultures between different academic disciplines at KTH vary greatly. While the majority of units publish in peer reviewed journals, some disciplines focus more on publishing books and others on publishing primarily in refereed conference proceedings, meaning that other criteria were found to be important to assess research excellence. Just as in 2008, the many centres of excellence at KTH were identified by the expert panels as catalysts for creating strong and mutually beneficial relationships with academia and industry.

12) Based on 3-year sliding averages of the field normalized citation rate for publications between 2004 and 2010. The value of e.g. 2007 is an average of the field normalized citation rate for publications from 2006 to 2008.

The recommendations for improvement by the expert panels at the KTH level were mostly associated with the need to invest in young research talent and research infrastructure for ensuring sustainable research environments in the future, promote gender equality and continue to strengthen the support for multi-disciplinary research and sustainable development, as well as strengthening several groups that were identified as having subcritical size or impact through consolidation with other groups. The expert panels also identified the need to strengthen groups with a strong basic research component.

Below, the key recommendations from the expert panels for KTH are summarized:

- Continue to focus on the support and development of young research talent through further strengthening of the new tenure track system
- Increase internationalization of the faculty to maintain intellectual diversity
- Work actively to attract top talent to groups identified as world-leading in their respective subject areas to further strengthen their position in a long-term perspective
- Increase mobility and internationalization of academic faculty
- Actively work for a more equal gender balance
- Strengthen the multidisciplinary research culture through developing the multidisciplinary technical platforms further
- Strengthen the integration of sustainable development into the KTH research base and education programs
- Increase the focus on the investment in research infrastructure and facilities for the future by developing long-term investment plans for research infrastructure at both school and KTH level
- Enhance KTH collaboration and engagement with industry, companies and other agencies in Sweden and work to enhance the wider impact of research on society, through further strengthening the exchange of staff and students between KTH and its partners

- Strengthen the base funding for basic scientific research to increase the prospect of long-term research commitments with higher risk and impact which have the potential to yield greater research rewards

- Reinforce the position of KTH as a leading European technical university through linking strategic goals with clearly measurable outcomes and benchmark KTH with other leading peer technical universities in Europe

- Increase the visibility of KTH research through strengthening the wider KTH impact on society

A key vehicle for change will be the next four-year (2013-2016) strategic plan for KTH. The outcomes from RAE2012 provide a valuable input to that process. At the same time, RAE2012 is a bottom-up process meaning schools, research groups and individual members of faculty can also make use of the findings in defining their own research strategies.

In summary, RAE2012 is helping KTH to further develop and sustain a dynamic and globally competitive research base that makes a major contribution to economic prosperity, national wellbeing and the expansion and dissemination of knowledge.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APPENDICES

Appendix A: RAE2012 evaluation package

Introduction

There are two parts to this self-evaluation package;

- Part A. Strategic reports from the Unit of Assessment (UoA)
- Part B. Quantitative data relating to the UoA

Parts A and B should be seen as complementary; together they should provide a full picture of the UoA regarding:

- Research output
- Impact and engagement with society
- Research environment

The period being assessed in RAE2012 is January 2008 to end of December 2011. The census date is December 31st, 2011. Staff employed at KTH on this date, and falling within the categories referred to in Tables B3.2.1, B3.2.2 and B3.2.3 of this document, will be included in RAE2012.

TABLE 0.1. GENERAL INFORMATION ABOUT THE UoA	
Unit of assessment:	
Unit of assessment coordinator:	
No professors within the UoA:	
Total size of UoA (all personnel):	
Research field:	
Research field coordinator:	

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

Part A of the evaluation package is designed to help the UoA develop and communicate a common research strategy that meets the objectives of high scientific quality, innovation potential and strategic relevance.

A1. DESCRIPTION OF RESEARCH FIELD

A1.1 SUMMARY DESCRIPTION OF RESEARCH FIELD

A2. IMPACT AND ENGAGEMENT WITH SOCIETY

Describe the UoA approach to supporting and enabling impact from research conducted within the UoA. This information is intended to enable a more holistic and contextualized assessment of impact than would be possible from case studies alone. It should include the following headings: a) context of possible impact, b) approach to impact, c) current and future strategy and plans for impact, and d) any relationship to the case studies provided.

Note: The completed impact statement should a) focus primarily on the approach taken by the UoA to achieving impact from its research, not the approach of KTH as a whole, b) not repeat detailed evidence that is included in case studies, although the completed impact statement could refer to submitted case studies, and c) include evidence and specific details or examples of the submitting UoA approach, rather than broad general statements.

A2.1 IMPACT STATEMENT

A3. RESEARCH ENVIRONMENT

A3.1 STRUCTURE OF THE UoA

A3.2 VISION FOR UNIT OF ASSESSMENT

A3.3. SELF-ASSESSMENT OF THE STRENGTHS, WEAKNESSES, OPPORTUNITIES AND CHALLENGES OF THE UNIT OF ASSESSMENT

A3.4 SUMMARY OF THE MOST PROMISING FUTURE RESEARCH DIRECTIONS OVER THE NEXT 8-12 YEARS OF THE UoA IN AN INTERNATIONAL AND STRATEGIC PERSPECTIVE

A3.5 FOLLOW-UP FROM RAE2008

A3.6 PEOPLE

A3.7 INFRASTRUCTURE, FACILITIES AND INCOME

A3.8 COLLABORATIONS AND CONTRIBUTIONS TO THE SUBJECT OR WIDER RESEARCH BASE

A3.9 IMPACT OF RESEARCH ON TRAINING OF DOCTORAL STUDENTS

Part B: Quantitative data of the UoA

This part of the evaluation package requests quantifiable information about the unit of assessment. Submissions in these sections should reflect and justify the descriptions provided in Part A. This part has three sections B1, B2 and B3.

- B1: Research output
- B2: impact and engagement with society
- B3: Research environment

Within each of these three sections, questions and tables are presented which support the statements made in Part A above.

B1: RESEARCH OUTPUT

B1.1 Introduction

Each UoA is asked to submit its major publications and other research output achieved during 2008-2011 to provide the strongest possible profile of the UoA.

Reflecting the status of KTH as a technical research university, in addition to printed academic work, other research outputs may be submitted that include, but are not limited to: new materials, devices, products and processes; patents; published papers in peer-reviewed journals; software, computer code and algorithms; standards documents; evidence synthesis, including systematic reviews, analyses, meta-analyses, meta-syntheses; review articles that add significant new perspective in a way that is paradigm-changing; research-based clinical case studies that add new knowledge; physical artefacts, such as buildings, devices, images, installations, materials products and processes, prototypes; digital artefacts, such as datasets, multi-use datasets, archives, software, film and other non-print media, web content such as interactive tools; temporary artefacts, such as exhibitions and performances.

B1.2 Scientific publications

Table B1.2.1: Total number of scientific publications produced by the UoA.

B1.2.1 SCIENTIFIC PUBLICATIONS (AS LISTED IN DiVA[1])					
Publication type (total number per year)	2008	2009	2010	2011	Total
Article in journal					
Article, review/survey					
Book					
Chapter in book					
Collection (editor)					
Conference paper (peer reviewed)					
Conference proceedings (editor)					
Report					
TOTAL					

1) Extracted after 14th February 2012.

B1.3 Major publication examples

Units of assessment will be asked to prepare four paper copies of each publication listed in Table B1.3.1 for use by the expert panel. Where the publication takes the form of a book, two copies should be provided. Units of assessment should be prepared to talk about and, where appropriate, demonstrate during the site visit of the expert panel all research outputs listed here.

Note: There is a maximum number of research output submissions. The number of research outputs, whether publication or other research output, is limited to the total number of professors within a UoA multiplied by four.

Table B1.3.1: Major peer-reviewed journal publication examples

B1.3.1 MAJOR PEER-REVIEWED PUBLICATION EXAMPLES			
Principal Author(s) – add rows as needed	Full Title	Journal, Year, Volume, Pages	DOI[2] if available

2) DOI=The Digital Object Identifier System, for scientific publications this is given e.g. in the following format: DOI: 10.1016/j.tibtech.2007.05.002

Table B1.3.2: Other major outputs

B1.3.2 OTHER MAJOR RESEARCH OUTPUTS			
Type of output (see examples below) Add rows as necessary	Principal person(s) responsible	Description	Date when became publicly available

Note 1: Recently submitted articles may be included.

Note 2: DOI should be inserted for written papers, or full publication details must be provided.

Options: books, book chapters, special issues, research monographs, conference contributions, reports, new materials, devices, products and processes, patents, software, computer code and algorithms, standards documents, evidence synthesis including systematic reviews, analyses, meta-analyses, meta-syntheses, review articles that add significant new perspective in a way that is paradigm-changing, research-based clinical case studies that add new knowledge, physical artefacts such as buildings, devices, images, installations, materials products and processes, prototypes, digital artefacts such as datasets, multi-use datasets, archives, software, film and other non-print media, web content such as interactive tools, temporary artefacts, such as exhibitions and performances.

B1.4 Innovation activities

As well as engaging with industry 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. software or experience. These activities are often referred to as 'innovation activities' and are highly valid outcomes for research conducted at KTH that will be regarded positively within this RAE. UoAs should enter those innovation activities undertaken during 2008-2011, noting their current status as of 31st December 2011.

Table B1.4.1: UoA IPs[3]

B1.4.1 INTELLECTUAL PROPERTY			
Patent Number[4]	Short Description	Person(s) involved at UoA	Date of Registration

3) Data should match that held in DiVA.

4) Awarded patents only, not patent applications.

Table B1.4.1 extra: UoA no. of outstanding patent applications and provisional patents

NO. OF OUTSTANDING PATENT APPLICATIONS 2011		NO. OF OUTSTANDING PROVISIONAL (I.E. US) PATENTS 2011	

Table B1.4.2: UoAs Companies founded

B1.4.2 COMPANIES FOUNDED				
Company Name[5]	Founder(s) from the UoA	Company type: spin-off[6], consultancy, service, other	Date of Formation	Current status e.g. company trading actively, company closed, company sold

5) To be included a company must have, or have had, an income in excess of 250 SEK per year.

6) A spin-off company should be based on results from KTH research activities.

B2: IMPACT AND ENGAGEMENT WITH SOCIETY

B2.1 Introduction

RAE2012 introduces the assessment of impact of excellent research undertaken within each UoA. In addition, activities related to engagement with society are to be highlighted within this section. Of interest are not only the unit's general approach to enabling impact and engagement from its research, but also specific examples of impacts that have been underpinned by research undertaken by the UoA.

B2.2 Impact case studies

The number of case studies required in each submission will be two (max). Each case study must provide details of a specific impact that meets the definition of impact for RAE2012, occurred during the period January 1st 2004 to December 31st 2011 and was underpinned by excellent research produced by the submitting unit in the period January 1st 1993 to December 31st 2011.

Table B2.2.1 Template for impact case studies

B2.2.1 IMPACT CASE STUDY (2 CASES/UoA)
2.2.1.1 Title of case study
2.2.1.2 Describe and provide evidence of the specific benefit or impact, including: • an explanation of the nature of the impact • how far-reaching the impact is/who the beneficiaries are • how significant the benefits are
2.2.1.3 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 • 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
2.2.1.4 Provide references to: • key research outputs that underpin the impact • external reports or documents, or contact details of a user, that could corroborate the impact or the UoA contribution

B2.3 Major engagement with society

Activities regarding engagement with society should be entered into one of three categories in the table below: Category 1 includes mobility between academia and industry which can be seen as a way to foster or strengthen strategic partnerships; Category 2 includes activities that are collaborative, usually representing a longer term commitment such as exchanged lectures with external (non-academic) organizations, the engagement of adjunct professors, and collaborative research projects with partners from industry; and, Category 3 includes one-way events such as public lectures, popular science publications, participation in science cafés, for example. The number of these activities per year should be given in each case.

Table B2.3.1: Major engagements with society

B2.3.1 CATEGORY 1 – MOBILITY BETWEEN ACADEMIC-INDUSTRY PARTNERSHIPS				
	2008	2009	2010	2011
No. of collaborative (including industry) doctoral students (no. of doctoral students each year whose research included a sizeable portion conducted with the collaboration of an external, non-academic organization)				
No. of temporary research positions outside KTH (UoA personnel who go outside KTH) (e.g. industry, local authority or hospital)				

B2.3.1 CATEGORY 1 – MOBILITY BETWEEN ACADEMIC-INDUSTRY PARTNERSHIPS (CONTINUED)				
	2008	2009	2010	2011
No. of adjunct professors, etc., brought into the UoA from outside KTH (no. of external persons, e.g. from industry, employed each year with a temporary position, e.g. adjunct professors)				
No. of publications co-authored with non-academics (e.g. book, popular article, scientific paper with someone from an external, non-academic organization)				

B2.3.2 CATEGORY 2 – COLLABORATION IN RESEARCH				
	2008	2009	2010	2011
No. of visits to external organizations (to an external, non-academic organization in order to meet for research discussions, networking events, collaboration talks)				
No. of guest lecture invitations to KTH (UoA) personnel (e.g. public lectures, talks to specialist groups, etc.)				
No. of research collaborations with external organizations (research projects where members of the UoA been involved with a non-academic partner, e.g. industry, local authority)				

B2.3.3 CATEGORY 3 – DISSEMINATION OF RESEARCH				
	2008	2009	2010	2011
No. of popular science publications (written articles, interviews or presentations in popular science magazines and other publications, including the internet)				
No. of lectures to the public (where the target audience, or a large portion of it, was the general public)				
No. of participations in TV or radio (presentations to a generalist audience)				
No. of participations in Open House events				
No. of participations in Science Cafés				

B3: RESEARCH ENVIRONMENT

B3.1 Introduction

As the staff at KTH is responsible for all of the university's achievements, it is critical that this resource at KTH is renewed and opportunities are created for merit-based advancement. In this section, UoAs should quantify those actions it has taken to renew and refresh its scientific staff. Again, information should be collected from 2008 to 2011. The aim of this section is to gauge the potential for quality at the UoA in future years.

B3.2 Staff statistics

This information will help the UoA and KTH identify the potential for renewal. The 'T' column is for the total staff number, the 'W' for number of women, and 'U' refers to the number of persons under 40 years of age.

Note: For the RAE2012 bibliometric analysis, as well as the research output information, all staff categories shown in Tables B3.2.1 and B3.2.2, are eligible (except for categories 4. Industry PhDs and 8. Other). Categories of staff listed in Table B3.2.3 are not included in the bibliometric study (except for category 1: Lecturer with docent title) but can participate in the research output parts (if research active).

Table B3.2.1: Research environment: Employed UoA research staff

B3.2.1 CATEGORIES OF KTH EMPLOYED RESEARCH STAFF	INDICATE NUMBER OF STAFF (FTE) (T: TOTAL, W: WOMEN, U: UNDER 40)											
Year	2008			2009			2010			2011		
PERMANENT & TENURE TRACK RESEARCH STAFF[7]	T	W	U	T	W	U	T	W	U	T	W	U
Professor (*professor*)												
Associate professor (*universitetslektor*)												
Assistant professor (*biträdande lektor*), tenure track												
Researcher (*forskare*), permanent												
TOTAL												

7) Staff categories in this table are included in the Research output part of RAE2012 as well as the bibliometric analysis.

Table B3.2.2: Research environment: Other UoA researchers

B3.2.2 OTHER RESEARCH CATEGORIES	INDICATE NUMBER OF STAFF (FTE) (T: TOTAL, W: WOMEN, U: UNDER 40)											
Year	2008			2009			2010			2011		
FIXED TERM & VISITING RESEARCH STAFF[8]	T	W	U	T	W	U	T	W	U	T	W	U
Researcher (*forskare*), fixed-term												
Research assistant (*forskarassistent*), non-tenure track												
Doctoral student (*doktorand*), employed at KTH												
Industry-employed doctoral student (*industridoktorand*)												
Visiting professor (*gästprofessor*)												
Adjunct professor (*adjungerad professor*)												
Post-doctoral researcher (*postdoktor*)												
Other (specify, e.g. post-docs on stipends)												
TOTAL												

8) Staff categories in this table are included in the Research output part of RAE2012 as well as the bibliometric analysis. The publications of eligible doctoral students will only be included in the bibliometric analysis if they were produced with a KTH affiliation, and do not otherwise appear in the bibliometric study (e.g. papers that were not co-authored with another KTH scientist, e.g. a supervisor).

Table B3.2.3: Research environment: Non-research staff in UoA

B3.2.3 OTHER NON-RESEARCH CATEGORIES	INDICATE NUMBER OF STAFF (FTE) (T: TOTAL, W: WOMEN, U: UNDER 40)											
Year	2008			2009			2010			2011		
TEACHING & NON-RESEARCH STAFF	T	W	U	T	W	U	T	W	U	T	W	U
Lecturer (*universitetsadjunkt*) – with docent title[9]												
Lecturer (*universitetsadjunkt*) – no docent title												
Research engineer (*forskningsingenjör*)												
Technical support (*tekniker*)												
Administrator (*administratör*)												
TOTAL												

9) Docent is a title based on scientific and teaching merits, and allows a researcher to supervise doctoral students as the main supervisor. This staff category has been added so that lecturers who publish regularly may be counted as part of the bibliometric analysis. All categories are included in Research output.

B3.3 Research funding

Amounts and sources of research funding for the UoA during 2008-2011 should be presented here.

Table B3.3.1: Research environment: External funding (spent money)

B3.3.1 EXTERNAL FUNDING SOURCE (KSEK)	2008	2009	2010	2011	TOTAL
Research councils (VR, FAS, Formas, etc.)					
Swedish Energy Agency & VINNOVA					
Other public bodies[10]					
Industry					
Swedish foundations (e.g. Wallenberg, Mistra, SSF)					
EU (FP7, ERC, etc.)					
Other international (including non-Swedish foundations)					
Other					
TOTAL					

10) Includes other Swedish agencies, county councils, regions and municipalities (*Swedish: övriga svenska myndigheter, länstyrelser, landsting och regioner samt kommuner*).

Table B3.3.2: Research environment: Total funding including GRU and FoFu (Income A3.7)

B3.3.2 AMOUNT OF FUNDING RECEIVED (KSEK)		2008	2009	2010	2011	TOTAL
External funding						
Internal funding	Education-related funding, not including doctoral student funding (*Swedish: grundutbildningsmedel*, GRU)					
Internal funding	Research and doctoral education funding (*Swedish: forskarutbildning*, FoFu)					
TOTAL TURNOVER *(SWEDISH: OMSÄTTNING)*						

B3.4 PhD degrees awarded

The total number of doctoral degrees (PhD, etc.) awarded by the UoA in the period 2008-2011 should be entered here. Again, the total number ('T') and number of women ('W') should be recorded per year.

Table B3.4.1: Research environment: Number of doctoral and licentiate degrees awarded

B3.4.1 DOCTORAL AND LICENTIATE DEGREES AWARDED								
	2008		2009		2010		2011	
	T	W	T	W	T	W	T	W
No. of doctoral degrees awarded								
No. of licentiate degrees awarded								
TOTAL								

B3.5 National and international centres of excellence

Here, a UoA should note all centres of excellence that it is or has been a member of during 2008-2011. All centres listed here must be in receipt of external income.

Table B3.5.1: Research environment: Participation in centres of excellence

B3.5.1 CENTRES OF EXCELLENCE						
Name of centre	Home-page	Person Responsible at the UoA	Role of UoA e.g. coordinator/ partner	Other partners	Total spent funding to the UoA (i.e. from the centre)	Duration

B3.6 Major international collaborations

Each UoA should record the number of major international activities undertaken with partners outside of Sweden during 2008-2011 by permanent research staff.

Table B3.6.1: Research environment: Global networks and collaborations

B3.6.1 GLOBAL NETWORKS AND COLLABORATIONS			TOTAL NO.
Number of collaborating institutions[11]			
No. of research visits abroad (of at least 2 months' duration), KTH outgoing researcher			
No. of visiting researchers (of at least 2 months' duration), incoming to KTH			
Number of EU research projects and international grants			
Name of project granted and role of UoA			
Project title	Funding body	Role (coordinator/partner)	Start Year
Other major international activities according to the traditions of the research field (please specify: scientific expeditions, field work, etc., and list below)[12]			Total No.

11) Research collaborations given here are limited to those with joint research grants and/or joint publications with the UoA.

12) A maximum of five examples in total may be provided.

B3.7 Leadership activities

UoAs should enter those activities undertaken during 2008-2011 that illustrate high quality leadership interactions with their scientific peers.

Table B3.7.1: Research environment: Leadership activities

B3.7.1 LEADERSHIP ACTIVITIES	
Type of activity	**Number**
Number of plenary or keynote talks at international conferences	
No. of assignments as editor or member of editorial board	
No. of memberships of international scientific councils	
No. of memberships of academic and learned societies	
No. of awards and prizes of international standing	
Research project coordinator (scientific coordination), specify each (e.g. FP7, ERC, VR, etc.)	Year
Expert evaluator, specify each (e.g. for the Swedish Research Council, EU, RAEs, etc.)	Year
Other, specify (e.g. hosting a major international conference, competition, exhibition)[13]	Year

13) A maximum of five examples in total may be provided; add rows as necessary.

B3.8 New recruitments

Table B3.8.1: Research environment: Permanent new recruitments

B3.8.1 NEW RECRUITMENTS (T: TOTAL, W: WOMEN)	NUMBER	
	T	W
External recruitments (with a doctoral exam from another Swedish university)		
Internal recruitments (with doctoral exam from KTH)		
International recruitments (with a doctoral exam from outside Sweden)		
TOTAL		

B3.9 Emerging talent

A UoA should note significant awards won by Research Staff under the age of 40. Awards of international standing recognising young talent e.g. Ingvar Carlsson, VR-Rådsforskarna, Göran Gustafsson, EU Young Scientist, European Research Council Starting Grant, EURYI (European Science Foundation Young Investigator Award), European Commission Marie Curie Excellence Grant, amongst others, should be noted.

Table B3.9.1: Research environment: Emerging talent

B3.9.1 EMERGING TALENT			
Name	M/F	Year	Type of award[14]

14) Choose from list above, for example.

Appendix B: RAE2012 Units of Assessment

RAE2012 consists of 13 Research Fields (RFs) divided into 47 Units of Assessment (UoAs). Each RF will be evaluated by one of 13 Panels of international experts.

Research Field 1: Mathematics

- 1.1 SCI Mathematics
- 1.2 SCI Mathematical Statistics
- 1.3 SCI Optimization & Systems Theory
- 1.4 CSC Numerical Analysis

Research Field 2: Information & Communication Systems

- 2.1 EES Information Processing, Networking & Control
- 2.2 ICT Communication: Services & Infrastructures

Research Field 3: Physics & Theoretical Physics

- 3.1 SCI Experimental Physics
- 3.2 SCI Theoretical Physics

Research Field 4: Applied Physics & Medical Technology

- 4.1 SCI Applied Physics & Medical Imaging
- 4.2 STH Medical Technology
- 4.3 ICT Materials Physics
- 4.4 ICT Optics & Photonics

Research Field 5: Energy Technology & Electrical Engineering

- 5.1 SCI Nuclear Power Safety, Reactor Physics & Reactor Technology
- 5.2 EES Electrical Power Engineering
- 5.3 EES Fusion & Space Plasma Physics
- 5.4 ITM Energy Technology

Research Field 6: Electronics & Photonics

- 6.1 EES Microsystems Technology (MEMS)
- 6.2 ICT Integrated Devices & Circuits
- 6.3 ICT Embedded Electronics & Computer Systems

Research Field 7: Applied Mechanics

- 7.1 SCI Vehicle Engineering
- 7.2 SCI Solid Mechanics
- 7.3 SCI Fluid Mechanics
- 7.4 SCI Mechanics-Biomechanics

Research Field 8: Industrial Technology & Management

- 8.1 ITM Industrial Product Development
- 8.2 ITM Production Engineering
- 8.3 STH Health (Ergonomics; Health & Building)
- 8.4 ITM Industrial Economics & Management

Research Field 9: Chemistry & Materials Science

- 9.1 CHE Chemistry
- 9.2 CHE Chemical Engineering
- 9.3 CHE Fiber & Polymer Technology
- 9.4 BIO Theoretical Chemistry
- 9.5 ITM Materials Science & Engineering

Research Field 10: Biotechnology

- 10.1 BIO Medical Biotechnology
- 10.2 BIO Industrial Biotechnology
- 10.3 BIO Proteomics
- 10.4 BIO Material Biotechnology

Research Field 11: Technology for the Built Environment

- 11.1 ABE Civil & Architectural Engineering
- 11.2 ABE Land & Water Resources Engineering
- 11.3 ABE Transport Science

Research Field 12: Architecture & the Built Environment

- 12.1 ABE Architecture
- 12.2 ABE Real Estate & Construction Management
- 12.3 ABE Philosophy & History of Technology
- 12.4 ABE Urban Planning & Environment
- 12.5 ITM Industrial Ecology

Research Field 13: Computer Science & Mediated Communications

- 13.1 CSC Theoretical Computer Science
- 13.2 CSC Applied Computer Science
- 13.3 CSC Mediated Communications

Appendix C: International Expert Panels and KTH coordinators

PANEL 1: MATHEMATICS

Expert Panel Members:

Chair	Marta Sanz-Solé	Professor, Faculty of Mathematics University of Barcelona
	Björn Birnir	Professor of Mathematics and Director of Center for Complex and Nonlinear Science, Department of Mathematics University of California Santa Barbara (UCSB)
	John A. Burns	Hatcher Professor of Mathematics and Technical Director, Interdisciplinary Center for Applied Mathematics, Department of Mathematics Virginia Polytechnic Institute and State University
	Ian Fialho	Dr., Technical Fellow at Boeing – Defense, Space and Security The Boeing Company
	Kathryn Hess Bellwald	Professor, SB MATHGEOM GR-HE Ecole Polytechnique Fédérale de Lausanne (EPFL)
	Helge Holden	Professor of Mathematics, Department of Mathematical Sciences Norwegian University of Science and Technology (NTNU)
	Rolf Jeltsch	Professor Emeritus and HC Andersen Academy Guestprofessor, Seminar for Applied Mathematics / Mathematics and Computer Science (IMADA) ETH Zurich / University of Southern Denmark
	Joel Spencer	Professor of Mathematics and Computer Science, Courant Institute, Departments of Mathematics and of Computer Science New York University

KTH Coordinators:

Research Field Coordinator:	Anders Forsgren	School of Engineering Sciences
Unit of Assessment Coordinators:	Sandra Di Rocco Boualem Djehiche Anders Forsgren Anna-Karin Tornberg	1.1 Mathematics 1.2 Mathematical Statistics 1.3 Optimization & Systems Theory 1.4 Numerical Analysis
Student Ambassadors:	Therese Askling Ulrika Nilsson	

PANEL 2: INFORMATION & COMMUNICATION SYSTEMS

Expert Panel Members:

Chair	Anthony Ephremides	Cynthia Kim Eminent Professor of Information Technology, Department of Electrical and Computer Engineering and Institute for Systems Research University of Maryland
	Urbashi Mitra	Professor, Ming Hsieh Department of Electrical Engineering University of Southern California (USC)
	Tor Arne Johansen	Professor, Department of Engineering Cybernetics Norwegian University of Science and Technology (NTNU)
	Visa Koivunen	Academy Professor, Department of Signal Processing and Acoustics Aalto University
	Alexander Reinefeld	Professor for Parallel and Distributed Systems and Head of Computer Science Department Zuse Institute Berlin
	Adam Wolisz	Professor of Electrical Engineering and Computer Science Institut for Telecom-munication Systems, Technische Universität Berlin
	Walter Tuttlebee	Dr., Director of WTIS Ltd (Wireless Technology Information & Strategy), UK

KTH Coordinators:

Research Field Coordinator:	Carl-Gustaf Jansson	School of Information and Communication Technology
Unit of Assessment Coordinators:	Mikael Skoglund Jens Zander	2.1 Information Processing, Networking & Control 2.2 Communication: Services & Infrastructures
Student Ambassadors:	Tanmoy Bari Sanzida Kabir	

PANEL 3: PHYSICS & THEORETICAL PHYSICS

Expert Panel Members:

Chair	Eric Jakobsson	Professor Emeritus and Director, National Center for Biomimetic Nanoconductors, Department of Molecular and Integrative Physiology University of Illinois at Urbana-Champaign
	Paula Chadwick	Dr., Reader in Astronomy, Department of Physics Durham University
	Gunnar Ingelman	Professor of Subatomic Physics and Dean of Physics, Department of Physics and Astronomy Uppsala University
	Paul Nolan	Professor of Physics, Department of Physics University of Liverpool
	Zara A. Sands	Dr., Senior Computational Medicinal Chemist, Chemistry Research UCB Pharma S.A., Brussels
	James A. Sauls	Professor of Physics, Department of Physics & Astronomy Northwestern University

KTH Coordinators:

Research Field Coordinator:	Olof Edholm	School of Engineering Sciences
Unit of Assessment Coordinators:	Mark Pearce Olof Edholm	3.1 Experimental Physics 3.2 Theoretical Physics
Student Ambassadors:	Anna Sandberg Emelie Utterström	

PANEL 4: APPLIED PHYSICS & MEDICAL TECHNOLOGY

Expert Panel Members:

Chair	Wolfgang Eberhardt	Professor, Institut für Optik und Atomare Physik Technische Universität Berlin
	Sabine Van Huffel	Professor in Biomedical Data Processing, Department of Electrical Engineering (ESAT) Katholieke Universiteit Leuven
	Ingolf Lindau	Professor, SLAC National Accelerator Laboratory Stanford University
	Pascal Van Peborgh	Dr., Partner and Managing Director Vanadis Capital, Stockholm
	Pekka Savolainen	Dr. Tech., Director of Optoelectronics Research Centre Tampere University of Technology (TUT)
	Peter Török	Professor of Optical Physics, Department of Physics Imperial College London
	Horst Vogel	Professor of Biophysical Chemistry and Head of the Laboratory of Physical Chemistry of Polymers and Membranes (LCPPM), Institute of Chemical Sciences and Engineering (ISIC) Ecole Polytechnique Fédérale de Lausanne (EPFL)

KTH Coordinators:

Research Field Coordinator:	Hans Hertz	School of Engineering Sciences
Unit of Assessment Coordinators:	Hans Hertz Kaj Lindecrantz Ulf Karlsson Ulf Karlsson	4.1 Applied Physics & Medical Imaging 4.2 Medical Technology 4.3 Materials Physics 4.4 Optics & Photonics
Student Ambassadors:	Helena Gistvik Henrik Roos	

PANEL 5: ENERGY TECHNOLOGY & ELECTRICAL ENGINEERING

Expert Panel Members:

Chair	Tuija Pulkkinen	Professor and Dean School of Electrical Engineering Aalto University
	Carlo Alberto Nucci	Professor, Chair of Power Systems and Deputy Dean of Faculty of Engineering, Department of Electrical Engineering University of Bologna
	Kevin Bennett	Professor and Director – Energy Research Centre, Department of Mechanical Engineering University of Cape Town
	Hardo Bruhns	Apl. Professor of Physics, Univ. Heidelberg / Advisor Dept. Chair Energy Working Group (AKE) in the German Physical Society
	Per Brunzell	AROS Nuclear Management Consulting AB, Västerås
	Alberto Cavallini	Professor Emeritus, Department of Industrial Engineering University of Padova
	Nouredine Hadjsaid	Professor and General Director IDEA GIE, G2ELab Grenoble Institute of Technology
	Marco E. Ricotti	Full Professor in Nuclear Power Plants, Department of Energy, CeSNEF-Nuclear Engineering Division Politecnico di Milano

KTH Coordinators:

Research Field Coordinator:	Hans-Peter Nee	School of Electrical Engineering
Unit of Assessment Coordinators:	Janne Wallenius	5.1 Nuclear Power Safety, Reactor Physics & Reactor Technology
	Lars Nordström	5.2 Electrical Power Engineering
	Lars Blomberg	5.3 Fusion & Space Plasma Physics
	Björn Palm	5.4 Energy Transformation
Student Ambassadors:	David Berg Sareh Sayidi	

PANEL 6: ELECTRONICS & PHOTONICS

Expert Panel Members:

Chair	Gehan Amaratunga	Professor, Department of Engineering University of Cambridge
	Eby G. Friedman	Distinguished Professor of Electrical and Computer Engineering, Department of Electrical and Computer Engineering University of Rochester
	Thomas Lewin	Retired, formerly at Ericsson, Gothenburg
	Markus Pessa	Professor Emeritus, Optoelectronics Research Centre Tampere University of Technology
	Arthur H.M. van Roermund	Professor in Microelectronics, Mixed-signal Microelectronics Eindhoven University of Technology
	Richard Syms	Professor of Microsystems Technology and Head, Optical and Semiconductor Devices Group, Department of Electrical and Electronic Engineering, Imperial College London

KTH Coordinators:

Research Field Coordinator:	Mikael Östling	School of Information and Communication Technology
Unit of Assessment Coordinators:	Göran Stemme Carl-Mikael Zetterling Axel Jantsch	6.1 Microsystems Technology (MEMS) 6.2 Integrated Devices & Circuits 6.3 Embedded Electronics & Computer Systems
Student Ambassadors:	Mohammad Abdulla Carl Brengesjö	

PANEL 7: APPLIED MECHANICS

Expert Panel Members:

Chair	Patrick Huerre	Professor of Mechanics, Hydrodynamics Laboratory – LADHYX École Polytechnique
	Nikolaus A. Adams	Full Professor and Chair of Aerodynamics, Director Institute of Aeroynamics and Fluid Mechanics Technische Universität München
	Sven-Åke Edström	Senior VP Truck, Cab and Bus Chassis Development SCANIA AB, Södertälje
	Steen Krenk	Professor of Structural Mechanics, Department of Mechanical Engineering Technical University of Denmark
	Robert McMeeking	Professor of Mechanical Engineering and of Materials, Department of Mechanical Engineering University of California Santa Barbara (UCSB)
	Roger Ohayon	Professor, Chair of Mechanics, The Structural Mechanics and Coupled Systems Laboratory (LMSSC) Conservatoire National des Arts et Métiers (Cnam), Paris
	R Ajit Shenoi	Professor and Director Southampton Marine and Maritime Institute University of Southampton
	Jerry Westerweel	Professor of Fluid Mechanics and Anthoni van Leeuwenhoek professor, Department of Process & Energy Delft University of Technology

KTH Coordinators:

Research Field Coordinator:	Dan Henningson	School of Engineering Sciences
Unit of Assessment Coordinators:	Leif Kari Jonas Faleskog Laszlo Fuchs Anders Eriksson	7.1 Vehicle Engineering 7.2 Solid Mechanics 7.3 Fluid Mechanics 7.4 Mechanics-Biomechanics
Student Ambassadors:	Marie Alexander Arshia Ebadi	

PANEL 8: INDUSTRIAL TECHNOLOGY & MANAGEMENT

Expert Panel Members:

Chair	Steve Evans	Professor and Director of Research in Industrial Sustainability, Department of Engineering University of Cambridge
	Hendrik Van Brussel	Professor Emeritus, Department of Mechanical Engineering Katholieke Universiteit Leuven
	Peter Buckle	Professor of Human Factors/Ergonomics, Department of Surgery and Cancer Imperial College London
	Eero Eloranta	Professor of Industrial Management and Vice Dean School of Science, Department of Industrial Engineering and Management Aalto University
	Klaus Janschek	Professor of Automation Engineering and Dean of Faculty Electrical and Computer Engineering (ECE) Institute of Automation, TU Dresden
	Per Langaa Jensen	Professor of Human Factors in Production Management, Department of Management Engineering Technical University of Denmark
	Masato Tanaka	Professor Emeritus, Department of Mechanical Engineering University of Tokyo
	James M. Utterback	David J. McGrath Jr. (1959) Professor of Management and Innovation Professor of Engineering Systems, Engineering Systems Division Massachusetts Institute of Technology (MIT)
	Engelbert Westkämper	Professor, Fraunhofer Institute for Manufacturing Engineering and Automation IPA University Stuttgart

KTH Coordinators:

Research Field Coordinator:	Jan Wikander	School of Industrial Engineering and Management
Unit of Assessment Coordinators:	Ulf Olofsson Lars Mattsson Jörgen Eklund Mats Engwall	8.1 Industrial Product Development 8.2 Production Engineering 8.3 Health (Ergonomics; Health & Building) 8.4 Industrial Economics & Management
Student Ambassadors:	Emre Sevket Köylüoglu Katarina Nilsson Lannerstedt	

PANEL 9: CHEMISTRY & MATERIALS SCIENCE

Expert Panel Members:

Chair	Erik W. Thulstrup	Professor of Chemistry, Department of Science, Systems and Models University of Roskilde
	Jacqueline Belloni	Professor and Directeur de Recherche Emérite, Laboratoire de Chimie Physique d'Orsay CNRS Université Paris-Sud
	Lars Gädda	Dr. Tech., Senior Advisor Forestcluster Ltd, Espoo, Finland
	Lauri Holappa	Professor Emeritus, Department of Materials Science & Engineering Aalto University
	Thomas Kolb	Professor for Fuel Technology and Head of Department of Chemical Engineering Karlsruhe Institute of Technology (KIT)
	François Lapicque	Research Professor in Chemical Engineering, ENSIC LRGP CNRS-Université de Lorraine
	Jean Marie André	Professor Emeritus, Chemistry Department University of Namur
	Tooru Matsumiya	Executive Advisor Nippon Steel Corporation and Visiting Professor Kanazawa University, Futtsu, Japan
	David Milstein	The Israel Matz Professor of Organic Chemistry and Director Kimmel Center for Molecular Design, Department of Organic Chemistry Weizmann Institute of Science Rehovot
	Stanislaw Slomkowski	Professor and Director of Center of Molecular and Macromolecular Studies, Department of Engineering of Polymer Materials Polish Academy of Sciences

KTH Coordinators:

Research Field Coordinator:	Mikael Lindström	School of Chemical Science and Engineering
Unit of Assessment Coordinators:	Tore Brinck Göran Lindbergh Mats Johansson Hans Ågren Pär Jönsson	9.1 Chemistry 9.2 Chemical Engineering 9.3 Fiber & Polymer Technology 9.4 Theoretical Chemistry 9.5 Materials Science & Engineering
Student Ambassadors:	Marc Pedersén Berta Pérez Gumà	

PANEL 10: BIOTECHNOLOGY

Expert Panel Members:

Chair	Bertil Andersson	Professor and President Nanyang Technological University (NTU)
Vice Chair	Hanno Langen	Professor of Biochemistry, University of Basel Global Head of Protein and Metabolite Technologies, F. Hoffmann-La Roche Ltd
	Dolores J. Cahill	Professor of Translational Science, UCD Conway Institute of Biomolecular and Biomedical Research University College Dublin
	Manuel J T Carrondo	Professor of Chemical and Biochemical Engineering, FCT-UNL, and Director IBET The Animal Cell Technology Unit (ACTU), and Instituto de Biologia Experimental e Tecnológica (IBET), Oeiras, Portugal
	Herfried Griengl	Professor of Organic Chemistry, Institute of Organic Chemistry Graz University of Technology
	Ivo Gut	Dr., Director National Genome Analysis Centre, Barcelona
	Markku S. Kulomaa	Professor of Medical Technology and Biotechnology, Molecular Biotechnology University of Tampere
	Catherine Martin	Professor, Department of Metabolic Biology John Innes Centre, UK

KTH Coordinators:

Research Field Coordinator:	Stefan Ståhl	School of Biotechnology
Unit of Assessment Coordinators:	Per-Åke Nygren Gen Larsson Mathias Uhlén Vincent Bulone	10.1 Medical Biotechnology 10.2 Industrial Biotechnology 10.3 Proteomics 10.4 Materials Biotechnology
Student Ambassadors:	Thomas Sjöholm Reza Zandi Shafagh	

PANEL 11: TECHNOLOGY FOR THE BUILT ENVIRONMENT

Expert Panel Members:

Chair	Cynthia Barnhart	Ford Professor of Engineering and Associate Dean of Engineering, Department of Civil and Environmental Engineering Massachusetts Institute of Technology (MIT)
	Thomas Bednar	Professor, Research Center of Building Physics and Sound Protection Vienna University of Technology
	Charles T. Driscoll	University Professor of Environmental Systems Engineering, Department of Civil and Environmental Engineering Syracuse University
	Dan M. Frangopol	The Fazlur R. Khan Endowed Chair of Structural Engineering and Architecture, Department of Civil and Environmental Engineering Lehigh University
	Joe Mahoney	The Conner Professor of Civil and Environmental Engineering, Department of Civil & Environmental Engineering University of Washington
	Suresh Rao	Lee A. Rieth Distinguished Professor of Civil Engineering and Agronomy, Division of Environmental and Ecological Engineering Purdue University
	Torbjörn Suneson	Director Strategic Development Swedish Transport Administration (*Trafikverket*), Borlänge

KTH Coordinators:

Research Field Coordinator:	Lars-Göran Mattsson	School of Architecture & the Built Environment
Unit of Assessment Coordinators:	Raid Karoumi Berit Balfors Lars-Göran Mattsson	11.1 Civil & Architectural Engineering 11.2 Land & Water Resources 11.3 Transport Science
Student Ambassadors:	Hussein Al-Haddad Sara Dughetti	

PANEL 12: ARCHITECTURE & THE BUILT ENVIRONMENT

Expert Panel Members:

Chair	Rachelle Alterman	Holder of the David Azrieli Professor Chair in Architecture/ Town Planning, Center for Urban and Regional Studies Technion – Israel Institute of Technology
	Peter Batey	Lever Professor of Town and Regional Planning, Department Of Civic Design University of Liverpool
	Frans Berkhout	Professor of Innovation and Sustainability and Director Institute for Environmental Studies (IVM) and Amsterdam Global Change Institute VU University Amsterdam
	Roland Clift	Emeritus Professor of Environmental Technology and Executive Director of the International Society for Industrial Ecology, Centre for Environmental Strategy University of Surrey
	Murray Fraser	Professor of Architecture and Global Culture, Bartlett School of Architecture University College London
	Patrick M. McAllister	Professor of Real Estate Appraisal, Henley Business School University of Reading
	Anthonie W.M. Meijers	Professor of the Philosophy and Ethics of Technology, Department of Philosophy Eindhoven University of Technology
	David E. Nye	Professor of History and American Studies and Chair Center for American Studies University of Southern Denmark
	Eeva-Liisa Pelkonen	Associate Professor (tenured), School of Architecture Yale University
	Frances Plimmer	Dr., Chair of FIG Commission 9 – Valuation and the Management of Real Estate International Federation of Surveyors (FIG), UK
	Tapani Sarjakoski	Professor and Head of Department, Geoinformatics and Cartography Finnish Geodetic Institute

PANEL 12: ARCHITECTURE & THE BUILT ENVIRONMENT

KTH Coordinators:

Research Field Coordinator:	Helena Mattsson	School of Architecture & the Built Environment
Unit of Assessment Coordinators:	Tim Anstey Hans Lind Sven Ove Hansson Göran Cars Ronald Wennersten	12.1 Architecture 12.2 Real Estate & Construction Management 12.3 Philosophy & History of Technology 12.4 Urban Planning & the Built Environment 12.5 Industrial Ecology
Student Ambassadors:	Sara Brolund de Carvalho Shler Moulodi	

PANEL 13: COMPUTER SCIENCE & MEDIATED COMMUNICATIONS

Expert Panel Members:

Chair	Mary Czerwinski	Research Manager, HCI, Visualization and Interaction (VIBE) Research Group Microsoft Research, Redmond
Vice Chair	Dieter Gollmann	Professor and Head of Department of Security in Distributed Applications Hamburg University of Technology (TUHH)
	Yali Amit	Professor Statistics and Computer Science, Department of Statistics and Department of Computer Science University of Chicago
	Helge Ritter	Professor and Coordinator Excellence Cluster 277, Cognitive Interaction Technology and Director Institute for Cognition & Robotics (CoR-Lab) Bielefeld University
	Isabel Trancoso	Professor, Institute for Systems and Computer Engineering- Research and Development (INESC-ID) Instituto Superior Técnico, Lisbon
	Esko Ukkonen	Professor of Computer Science and Head of Department of Computer Science University of Helsinki

KTH Coordinators:

Research Field Coordinator:	Anders Askenfelt	School of Computer Science and Communication
Unit of Assessment Coordinators:	Johan Håstad Danica Kragic Jan Gulliksen	13.1 Theoretical Computer Science 13.2 Applied Computer Science 13.3 Mediated Communications
Student Ambassadors:	Erik Lindström Tim Malmström	

Appendix D: Submitted Impact Cases

UoA	TITLE
1.1	Computational number theory and fast arithmetic
1.1	Video compression
1.2	Risk aggregation In insurance with regards to Solvency II
1.2	Risk-based asset alocation in the presence of fat tailed distributions
1.3	Untitled 1
1.3	Untitled 2
1.4	COMSOL AB
1.4	EFIELD AB
2.1	4G wireless cellular systems
2.1	Energy-efficient and safe intelligent road transportation
2.2	Pandemic preparedness
2.2	QUASAR - Technical, Business and Regulatory Feasibility of Secondary Spectrum use
3.1	Radioactive Orchestra
3.1	Stockholm Schools' Cosmic Network
3.2	The GROMACS Molecular Dynamics Simulation & Modeling Toolkit
3.2	Experimental and theoretical studies of copper corrosion in pure anoxic water
4.1	MicroDose Mammography
4.1	Liquid-metal-jet x-ray tube
4.2	Tissue Doppler Imaging (TDI) and its applications for improved evaluation of cardiac function
4.2	Research and Development of helmets with optimal energy absorption
4.3	Research leading to Scint-X spin-off company
4.3	Research leading to MicroDeltaT AB spin-off company
4.4	JORCEP
4.4	Creation of Photonics 21 and research cooperation with HP Laboratories
5.1	ELECTRA: A Swedish Generation IV reactor project
5.1	Implementation of the sub-cooled boiling model in the commercial CFD code CFX
5.2	High Performance Electric Drives
5.2	Smartgrid Policy making
5.3	ITER-Like Wall at the JET Tokamak: Selection of First Wall Materials and Impact on the Cost/Schedule of ITER
5.3	Impact of the KTH contributions to the European Space Agency multi-satellite mission Cluster, one of four cornerstones of the ESA Horizon 2000 programme

UoA	TITLE
5.4	The Sustainable Energy Engineering (SEE) MSc Program at KTH – A unique arena with global outreach in sustainable development and innovation
5.4	KTH, a center for heat pump development in Europe
6.1	Ultra-miniaturized pressure sensor catheters for blood pressure measurements
6.1	Silex Microsystems AB
6.2	World-leading research in SiC high voltage switches spun off in company TranSiC AB
6.2	Silicon device research leading to strong EU networks, ERC grant and possibly EU flagship
6.3	National Vinnova excellence centre in ubiquitous intelligence in paper and packaging: iPack Vinn Excellence Center
6.3	Education outreach for impact
7.1	Multi-functional roof panel (MFB)
7.1	Development of active suspension for a high speed rail vehicle
7.2	Solid Mechanics modeling for design
7.2	Rupture risk assessment of aneurysm patients
7.3	The CAPPI-laboratory: fluid mechanics for improved papermaking and new materials from wood
7.3	Laminar wing design
7.4	Large Space Structure for Space Solar Power: Sounding Rocket Technology Demonstration as a Student Space Project.
7.4	Contribution to the architecture and development of COMSOL Multiphysics
8.1	Research for Impact - Industrial Product development
8.1	Airborne particle emissions
8.2	IDEAS (Instantly Deployable Evolvable Assembly Systems) assembly system demonstrator
8.2	High Strength NanoDamping Material and Anti-Vibration Engineering Applications
8.3	Inclusive design for the life-long dwelling
8.3	Development of a new ventilated welding visor
8.4	Gender Equality Work at Volvo Group
8.4	The Swedish Globalization Council
9.1	Geological Disposal of Spent Nuclear Fuel: The World's Largest Coordinated Environmental Project
9.1	Environmental and Health Aspects induced by Corrosion of Metals and Alloys – Importance for Risk Assessment and Sustainable actions
9.2	The emerging field of fuel cells
9.2	Swedish Gasification Centre
9.3	Novel polymer concepts implemented into full scale production

UoA	TITLE
9.3	New material concepts for the use of forest raw materials
9.4	An optical power limiting material for laser protection
9.4	Standoff detection system for identification of foreign substances
9.5	The Materials Genome
9.5	Nanotechnology laboratory, Div. Engineering Materials Physics.
10.1	Clinical in vivo imaging of HER2 positive tumors: decisions concerning life and death
10.1	Massive Parallel Sequencing and high throughput biology: new possibilities in life sciences.
10.2	Pyrosequencing – a new DNA sequencing technology
10.2	Bioproduce – a research dissemination platform
10.3	The Human Protein Atlas program
10.3	Engineering of protein A for antibody purification and handling
10.4	Modification of cellulosic fibers: from fundamental research to innovation, technology transfer and commercialization
10.4	Engineering of plant cell walls: potential exploitation in economically relevant crops
11.1	Sealing of rock for rock tunnelling and rock foundation
11.1	Building performance modelling
11.2	Spreading of pollutants from roads
11.2	Three techniques for obtaining pure water
11.3	The Stockholm Congestion Charging System
11.3	Improving Public Transport Service Reliability
12.1	Albano Sustainable Campus – towards principles of social-ecological urban design
12.1	Peepoo
12.2	Impact on legislation in the real estate area
12.2	Valueguard property index
12.3	More science-based chemicals policies
12.3	Changed policy for state support to industrial research institutes
12.4	A successful tool for environmental certification of buildings
12.4	The Livable City – Den Goda Staden
12.5	Sustainable Urban Development with an Industrial Ecology Approach
12.5	Sustainable fuels from algaes and organic waste
13.1	Verificatum Mix-Net
13.1	GMP
13.2	Virtual and Physical Talking Avatars and their role in Assistive Technology
13.2	Robotics: from research to society
13.3	Founding the Scandinavian tradition of Collaborative design and bringing it into the future
13.3	Leading the field of Sustainable Communication

Appendix E: Bibliometric indicators

The appendix gives a full description of the indicators used in the bibliometric analysis.

Total number of publications in DiVA (P_{DiVA})

Denotation	Designation	Data source	Methodological remarks	Time period
P_{DiVA}	Total number of publications in DiVA	DiVA	Full count. All authors are assigned the full publication.	2004-2011

The total number of publications in DiVA is the sum of all publications retrieved from DiVA by the search criterion at the time of data extraction. The following document types have been counted in KTH RAE2012:

- Article in journal (peer review)
- Article in journal (other)
- Article, review/survey
- Book
- Book Review
- Chapter in book
- Collection/Anthology (editor)
- Conference paper
- Conference proceedings (editor)
- Doctoral thesis
- Licentiate thesis
- Patent
- Report

Number of publications in Web of Science (P_{WoS})

Denotation	Designation	Data source	Methodological remarks	Time period
P_{WoS}	Number of publications in Web of Science	Web of Science	Full count. All authors are assigned the full publication. Journal articles, letters, review articles and proceedings papers included.	2004-2011

The number of publications in Web of Science is the sum of all publications retrieved by the search criterion, which are also indexed in Web of Science at the time of data extraction.

Number of publications in Web of Science, author fractionalized (P_r)

Denotation	Designation	Data source	Methodological remarks	Time period
P_r	Number of publications in Web of Science, author fractionalized	Web of Science	Fractionalization on author. Journal articles, letters, review articles and proceedings papers included.	2004-2011

The author fractionalized number of publications in Web of Science is the sum of a unit's publications after assigning each publication the value 1 and dividing the assigned value with the number of authors.

Web of Science visibility (p_{WoS})

Denotation	Designation	Data source	Methodological remarks	Time period
p_{WoS}	WoS visibility	DiVA and Web of Science	Full count. All authors are assigned the full publication.	2004-2011

The Web of Science visibility factor is calculated by dividing the number of publications in Web of Science with the number of publications in DiVA.

Formula: $$p_{WoS} = \frac{P_{WoS}}{P_{DiVA}}$$

Number of publications used in the citation count (P_C)

Denotation	Designation	Data source	Methodological remarks	Time period
P_C	Number of publications in citation count	Web of Science	Full count. All authors are assigned the full publication.	2004-2010

The number of publications in the citation count is the sum of all publications forming the bases for the count of citations.

Share of publications used for the calculation of field normalized citation rate (p_{cf})

Denotation	Designation	Data source	Methodological remarks	Time period
p_{cf}	Share of publications used for the calculation of field normalized citation rate	DiVA and KI bibliometric system	Full count. All authors are assigned the full publication.	2004-2010

The share of publications used for the calculation of field normalized citation rate is calculated by dividing the number of publications in the database used for the calculation of the field normalized citation rate with the total number of publications in DiVA.

Formula: $$p_{cf} = \frac{P_{cf}}{P_{DiVA}}$$

Publications published in level 2 journals (P_{lev2})

Denotation	Designation	Data source	Methodological remarks	Time period
P_{lev2}	Publications published in level 2 journals	DiVA and Norwegian Journal Evaluation categories	Full count. All authors are assigned the full publication. Based on DiVA category "article in journal".	2004-2011.

The P_{lev2} indicator is the number of publications that have been published in level 2 journals by the Norwegian journal evaluation categories. 20% of the journals in each field are classified into level 2 by this system.

Journals' field normalized impact (j_{cf})

Denotation	Designation	Data source	Methodological remarks	Time period
j_{cf}	Journals' field normalized impact	KI bibliometric system	Full count. All authors are assigned the full publication. Self-citations included. Journal articles, letters and review articles included.	2004-2010. Open citation window April 2012

The field normalized citation rate (c_f) is calculated for each article published in the journal the 3 preceding years and then an average c_f value is calculated for the journal. This results in a value similar to the Thomson Reuters' Journal Impact Factor (JIF), but is adjusted for differences in publication and citation rates within different research fields. The result is an indicator that shows the journals' relative impact related to the research field where it is classified. Finally, an average of the journals' field normalized citation rates is calculated for the analyzed unit.

The value is only calculated for journals classified into fields consisting of 30 publications or more and that have a field norm higher than 0.2, since small norm values and small fields causes unstable results.

Formula: $$j_{cf} = \frac{1}{P} \sum_{i=1}^{P} \left[\frac{1}{P_{J_3}} \sum_{j=1}^{P_{J_3}} [c_f]_j \right]_i$$

Where: P is the analyzed unit's number of publications. Each publication is denoted i.
P_{J_3} is the number of publications in journal J during 3 years precedent to the year of publication. Each publication is denoted j.
$[c_f]_j$ is the c_f value for publication j in the journal J.

Total number of citations (C)

Denotation	Designation	Data source	Methodological remarks	Time period
C	Total number of citations	Web of Science	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters, review articles and proceedings papers included.	2004-2010 Open citation window April 2012

The total number of citations is the sum of citations to all of the unit's publications in the data source.

Number of citations, author fractionalized (C_r)

Denotation	Designation	Data source	Methodological remarks	Time period
C_r	Number of citations, author fractionalized	Web of Science	Fractionalization on author. Self-citations included. Journal articles, letters, review articles and proceedings papers included.	2004-2010 Open citation window April 2012

The author fractionalized number of citations is the sum of a unit's citations to a publication set after dividing the number of citations for each publication with the number of authors of that publication.

Citations per publication and year (c_{py})

Denotation	Designation	Data source	Methodological remarks	Time period
c_{py}	Citations per publication and year	Web of Science	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters, review articles and proceedings papers included.	2004-2010. Open citation window April 2012

The average number of citations per publication and year is calculated by initially dividing the number of citations for each of the publication with the number of years since publication. The sum of citations per year is then divided by the number of publications.

Formula: $$c_{py} = \frac{1}{P} \sum_{i=1}^{P} \frac{C_i}{Y_a - [Y_p]_i}$$

Where: P is the total number of publications.
C_i is the total number of citations to publication i.
Y_a is the year when data was extracted (year of analysis).
$[Y_p]_i$ is the publication year for the publication i.

Average field normalized citation rate (c_f)

Denotation	Designation	Data source	Methodological remarks	Time period
c_f	Average field normalized citation rate	KI bibliometric system	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters and review articles included.	2004-2010. Open citation window April 2012

The average field normalized citation rate is calculated by first dividing the number of citations to each of the publications of the analyzed unit with the average number of citations to publications published in journals assigned within the same subject category, published the same year and of the same document type, i.e. the field citation rate (μ_f). Thereafter an average of these citation rates is calculated.

If the journal which a publication is published within is assigned more than one subject category an average of the field citation rates is set in the denominator. If the field citation rate is less than 1 the value is set to 1 since such low field citation rates could cause unreasonable high field normalized citation rates.

Formula: $$c_f = \frac{1}{P} \sum_{i=1}^{P} \frac{C_i}{[\overline{\mu_f}]_i}$$

Where: P is the number of publications.
C_i is the number of citations to publication i.
$[\overline{\mu_f}]_i$ is the average field citation rate for the publication i.

Share of publications among the 10% most cited in the field (p_{top10})

Denotation	Designation	Data source	Methodological remarks	Time period
p_{top10}	Share of publications among the 10% most cited in the field	KI bibliometric system	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters and review articles included.	2004-2010. Open citation window April 2012

The p_{top10} indicator is the share of publications that is among the 10 per cent most cited publications published in journals categorized within the same subject category, the same publication year and of the same document type.

Share of publications not cited (p_u)

Denotation	Designation	Data source	Methodological remarks	Time period
p_u	Share of uncited publications	Web of Science	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters, review articles and proceedings papers included.	2004-2010. Open citation window April 2012

The share of uncited publications is the percentage of publications that was uncited at the time of data extraction.

Time series of the sliding 3-year average field normalized citation rate 2004-2010

Denotation	Designation	Data source	Methodological remarks	Time period
c_{f3}	Time series of the sliding 3-year average field normalized citation rate	KI bibliometric system	Full count. All authors are assigned all of the citations to the publication. Self-citations included. Journal articles, letters and review articles included.	2004-2010. Open citation window April 2012

A three years average including the year before and after the year assigned with the value. The value for the first and last year is the average of 2 years since values for 3 years are not available. The sliding 3-years average field normalized citation rate is presented as a time series.

Authors per publication (a_p)

Denotation	Designation	Data source	Methodological remarks	Time period
a_p	Authors per publication	Web of Science		2004-2011

The average number of authors per publication is the sum of the number of authors of a set of publications divided by the number of publications.

Countries per publication (i_p)

Denotation	Designation	Data source	Methodological remarks	Time period
i_p	Countries per publication	Web of Science		2004-2011

The average number of countries per publications is calculated by dividing the sum of countries in the address field for a set of publications with the number of publications.

Publications co-authored internationally (p_i)

Denotation	Designation	Data source	Methodological remarks	Time period
p_i	Publications co-authored internationally	Web of Science		2004-2011

The share of publications co-authored internationally is the percentage of publications containing at least 2 different countries among the author addresses.

Appendix F: Biographies of the Chairpersons

Marta Sanz-Solé

Chair, Panel 1 – Mathematics

Marta Sanz-Solé studied mathematics at the University of Barcelona where she completed her PhD in 1978. Since 1986 she holds a position as full professor at the faculty of mathematics at that university. She has been former dean and also vice-president for research at the sciences division of the university.

Professor Sanz-Solé has had numerous visiting positions abroad, most recently at Centre Interfacultaire Bernoulli, EPFL in Switzerland and at Isaac Newton Institute for Mathematical Sciences, Cambridge in the UK. In 1998 she received the Narcis Monturiol Award of Scientific and Technological Excellence, granted by the autonomous government of Catalonia.

Professor Sanz-Solé's current research interests lie in stochastic analysis, including stochastic calculus of variations, stochastic partial differential equations, probabilistic potential theory and large deviations. She is the director of the research group on stochastic processes at her university.

In 2011, Professor Sanz-Solé was elected Fellow of the Institute of Mathematical Statistics for influential work in a variety of branches of stochastic analysis. Since 2011, she is the President of the European Mathematical Society, a learned society whose mission is to promote the development of all aspects of mathematics in Europe, in particular mathematical research, relations of mathematics to society, relations to European institutions and which boasts the second world's largest congress in mathematics.

Anthony Ephremides

Chair, Panel 2 – Information & Communication Systems

Anthony Ephremides holds the Cynthia Kim Eminent Professorship Chair of Information Technology at the University of Maryland. He holds a joint appointment with the Institute for Systems Research, of which he has been a founding member, and he is also a member of and former co-director of the Maryland Hybrid Networks Center (HyNET), formerly known as the Center for Hybrid and Satellite Communication Networks (CHSCN). He was also named distinguished university professor at the University of Maryland in June 2012.

Professor Ephremides received his BSc in electrical and computer engineering from the National Technical University of Athens, Greece, in 1967 and MA and PhD degrees also in electrical engineering from Princeton University in 1969 and 1971, respectively.

He has served in many capacities in the IEEE and other organizations, from local organization posts to president of the Information Theory Society and member of the Institute Board of Directors, including technical programme chair and general chair of major conferences. He is the recipient of numerous awards.

Professor Ephremides' interests span the field of information sciences and systems such as communications systems (information theory, communication theory, multi-user systems, communication networks, satellite systems), systems theory, stochastic systems, signal processing and wireless communications.

Eric Jakobsson

Chair, Panel 3 – Physics & Theoretical Physics

Eric Jakobsson is an interdisciplinary computational scientist and a Fellow of the American Physical Society whose work has been published in journals as diverse as Biophysical Journal, Genome Science, Nano Letters, Journal of Physical Chemistry B, Journal of Theoretical and Computational Chemistry, Journal of Chemical Physics, and the Journal of Physiology (Cell Physiology).

Professor Jakobsson received a PhD in physics at Dartmouth College in 1969. He was a post-doctoral researcher at the Department of Physiology, Case Western Reserve University School of Medicine. His long-time academic appointment, since 1971, has been in the Department of Molecular and Integrative Physiology at the University of Illinois. Since 1991 he has been housed at the interdisciplinary Beckman Institute and affiliated with the National Center for Supercomputing Applications at Illinois.

His group pioneered in Brownian dynamics simulations of ion permeation in protein channels, in computational methods for identifying prokaryotic counterparts of eukaryotic proteins, in modelling osmotic effects of ion motion across biological membranes, and in force field development for multiscale molecular simulations.

He is also the Director of the National Center for Biomimetic Nanoconductors and a major product under his direction is the nanoengineered protocell, which is being developed as a vector for cancer therapy, antimicrobial therapy, antiviral therapy, and a platform for synthetic biology. He has also developed educational applications for computational biology research tools, as exemplified in the Biology Student Workbench project.

Professor Jakobsson's research interests span a wide variety of areas such as computational genomics, multiscale simulation, development of force fields for computational biochemistry, and nanoscience and antimicrobial therapy.

Wolfgang Eberhardt

Chair, Panel 4 – Applied Physics & Medical Technology

Wolfgang Eberhardt studied physics at the Justus Liebg Universität in Giessen, where he completed his PhD in 1974, and at the Universität Hamburg, where he was awarded a second PhD in 1978. After his doctoral work, Professor Eberhardt took a position as assistant professor in physics at the University of Pennsylvania, followed by a position as an associate physicist at the Brookhaven National laboratory and then as a physicist at Exxon Research and engineering. Following his 12 years in the USA he returned to Germany to take up the position of director of IFF (Institute of Solid State Research) at the Jülich Reseach Center with a joint professorship in physics at the University of Cologne, Germany.

Between 2001 and 2008, Professor Eberhardt was the scientific director of BESSY Gmbh Germany (Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung). He was also appointed professor in physics at TU Berlin, Germany during this period, and he remains in this position. In 2003 he was awarded an honorary doctorate from Uppsala University, Sweden. In 2008 BESSY and HMI merged and Helmholtz-Zentrum Berlin was established. At this new centre Professor Eberhardt was selected to be the scientific director, a position which he held for three years to 2011 when he took on a position as a leading scientist in at HZB and DESY-CFEL.

Professor Eberhardt's research areas are many and include topics such as electronic properties of matter, synchrotron radiation and free electron lasers, clusters and nanostructures and renewable energy.

Professor Eberhardt is a member of numerous scientific advisory boards and as part of his work he was involved in formulating two recent reports for the US Department of Energy.

Tuija Pulkkinen

Chair, Panel 5 – Energy Technology & Electrical Engineering

Tuija Pulkkinen was appointed dean of the newly formed Aalto University School of Electrical Engineering in 2011. Her specialist fields are research of the near-Earth space environment, space plasma physics and the northern lights. Since 2008, Professor Pulkkinen has been the president of the EGU, the European Geosciences Union. She is a member of the Finnish Academy of Science and of the Letters, and the Societas Scientiarum Fennica, as well as of the Royal Astronomical Society.

Professor Pulkkinen completed her PhD in the field of space physics at the University of Helsinki in 1992. She joined the Finnish Meteorological Institute in 1988 and was promoted to research professor in 2000. At the Institute she headed first the Space Research Unit and later the Earth Observation Unit.

She has spent over two years in the US, as a visiting research associate at the Laboratory of Atmospheric and Space Physics of the University of Colorado and as a visiting professor at the Los Alamos National Laboratory. She has also been a visiting scientist at the Laboratory for Extraterrestrial Physics at NASA Goddard Space Flight Center during the years 1990-1992.

Her research interests concern the plasma-physical processes of the Sun-Earth connection, including the solar activity, solar wind disturbances and their effects in the Earth's space environment, upper and middle atmosphere. Research methodologies include use of space-based observations, empirical data based modelling, and numerical space plasma simulations.

Gehan Amaratunga

Chair, Panel 6 – Electronics & Photonics

Gehan Amaratunga obtained his BSc from Cardiff University and a PhD from Cambridge, both in electrical/electronic engineering. He has held the 1966 Professorship in Engineering at the University of Cambridge since 1998. He currently heads the Electronics, Power and Energy Conversion Group, within the electrical engineering division of the Cambridge engineering faculty.

Professor Amaratunga has an active research programme on the synthesis and electronic applications of carbon nanotubes and other nanoscale materials. His group has many 'firsts' emanating from his research in carbon, including field emission from N-doped thin film amorphous carbon and diamond, laboratory synthesis of carbon nanonions, tetrahedral amorphous carbon ('amorphous diamond')-Si heterojunctions, deterministic growth of single isolated carbon nanotubes in devices, high current nanotube field emitters and the polymer-nanotube composite solar cells.

His group was amongst the first to demonstrate integration of logic level electronics for signal processing and high voltage power transistors in a single IC (chip). He is a founder of CamSemi – which is commercializing a new generation of power and mixed-signal ICs for power management He is also a founder of Enecsys, the solar micro-inverter company.

Professor Amaratunga has previously held faculty positions at the Universities of Liverpool (95-98), Cambridge (86-95), and Southampton (83-86). Currently he is also visiting professor at the Nanyang Technological University, Singapore and chief of research at the Sri Lanka Institute of Nanotechnology. Professor Amaratunga was elected a Fellow of the Royal Academy of Engineering in 2004. In 2007 he was awarded the Royal Academy of Engineering Silver Medal 'for outstanding personal contributions to British engineering'.

Patrick Huerre

Chair, Panel 7 – Applied Mechanics

Patrick Huerre received his ingénieur's degree from École Centrale Paris in 1970 and his PhD in aeronautical sciences from Stanford University in 1976. After postdoctoral work at the University of Leeds with the late professor David Crighton, he joined the faculty of the Department of Aerospace Engineering at the University of Southern California (USC) in 1978. In 1989 he was appointed professor of mechanics at École Polytechnique. Since 1991, he has also been director of research at the French National Center for Scientific Research. Professor Huerre was the founder and director of the Hydrodynamics Laboratory (LadHyX) at École Polytechnique in the period 1990-2008.

Professor Huerre is president of the European Mechanics Society. He was associate editor of the Journal of Fluid Mechanics between 1999 and 2009, and he has served on several committees and panels in Europe and in the United States.

He is a member of the Académie des Sciences, a Fellow of the American Physical Society and also Chevalier de la Légion d'Honneur.

His research areas of interest cover a wide variety of hydrodynamic instabilities and transition phenomena in shear flows. His main research achievements include the effective use of absolute/convective instability concepts to rigorously distinguish between amplifiers and oscillators in fluid mechanics, the introduction of the notions of linear and nonlinear global mode and associated frequency selection criteria to account for the dynamics of oscillators and the identification of super-directivity as a key mechanism for the production of sound in shear flows.

Steve Evans

Chair, Panel 8 – Industrial Technology & Management

Steve Evans spent 12 years in industry, rising to become engineering systems manager at Martin-Baker Engineering, the world leading manufacturer of ejection seats.

Professor Evans has been professor of life cycle engineering at Cranfield University since 1998, where he has supervised over 120 PhD and MSc students. More recently, Professor Evans joined the Institute for Manufacturing at the University of Cambridge where he is director of research at the national EPSRC Centre for Innovative Manufacturing in Industrial Sustainability.

Professor Evans' research seeks a deep understanding of how industry brings environmental and social sustainability concerns into its design and manufacturing practices, with a duel emphasis on urgent & practical change now and system level change that offers hope for a sustainable future.

He works with organizations to develop solutions that move us towards a sustainable future. His work includes sustainable factories, food systems for people with reduced access to food, sustainable city re-generation design, sustainable design and operations for mainstream car manufacturers, and cars with water for exhaust that do 280 mpg (equivalent).

Professor Evans has acted as specialist adviser on waste reduction to the House of Lords, is board member of the Centre for Sustainable Engineering and is a partner in two cleantech start-ups.

Erik W Thulstrup

Chair, Panel 9 – Chemistry & Materials Science

Erik W Thulstrup graduated from the MSc programme in chemistry and physics at Aarhus University 1967. His MSc was followed by a PhD in 1970 and a Dr Scient in 1980, also from Aarhus University. In 1993 he was appointed professor in chemistry at Roskilde University, where he now is professor emeritus.

Professor Thulstrup's research interests include polarization spectroscopy where he developed a method with a wide range of applications, from cancer research to flat television screens. He is the author of three leading monographs in this field. Furthermore, his interests lie within science and development, in particular the role of research and education for economic development, where he is involved in extensive science policy and research evaluation work in eastern Europe, Africa, east and south Asia, and Latin America. Within the latter research area he has also helped introduce output based evaluations in the World Bank.

He has been leader in several large scale evaluations for example Danish support for research in developing countries, Swedish (SIDA) research support for several countries, the International Foundation for Science, Swedish university cooperation with developing countries, Danish polymer research and several others.

Professor Thulstrup was the head of the World Bank S&T programme 1989-93 and has held numerous visiting positions in different countries. He was the president in the Danish National Commission UNESCO from 1993 until 1995.

Professor Thulstrup has also received several honours and gold medals such as from Aarhus University in 1969, the Polish Academy of Sciences in 2006, and the Panama Science Society in 2010. He is also a fellow of several academic societies including TWAS, the Norwegian Academy of Sciences, the Mongolian Academy of Sciences and the African Academy of Sciences.

He has published more than 250 publications which have been cited more than 5,000 times.

Bertil Andersson

Chair, Panel 10 – Biotechnology

Bertil Andersson has a PhD from Lund University in Sweden. He became a professor of biochemistry at Stockholm University in 1986. In 1996 he became dean of the faculty of chemical sciences at the University of Stockholm. During the years 1999 and 2003 he was rector (president) of Linköping University, Sweden. From 2004-2007, he joined the European Science Foundation in Strasbourg as its chief executive. He was appointed Nanyang Technological University's (NTU) first provost in April 2007 and was installed as third NTU president on 1 July 2011.

Professor Andersson is a plant biochemist and author of over 300 papers in photosynthesis research, biological membranes, protein and membrane purification and light stress in plants. He is also an author of a number of articles devoted to popular sciences and science policy.

From 1989 to 1997, he was member of the Nobel committee for chemistry (chair 1997), later becoming a member of the Nobel Foundation (2000-2006), and is currently a member of the Board of Trustees of the Nobel Foundation.

Professor Andersson has been a member of the boards of several Swedish and international foundations and learned societies, including the Royal Swedish Academy of Sciences, the Australian Academy of Sciences and Academia Europaea and holds honorary doctorates from several universities. He is also a member of the Science and Engineering Research Council (SERC) board, A*STAR Singapore. He continues to hold academic appointments as professor of biochemistry at Linköping University and adjunct professor at Umeå University. He is also a visiting professor and a Fellow of Imperial College London.

Professor Andersson is also a research adviser to the Swedish government and was, between 2004 and 2007, the vice president of the European Research Advisory Board (EURAB) of the European Commission. He has also been an adviser regarding business activities in the area of biotechnology and pharmaceuticals.

Hanno Langen

Vice Chair, Panel 10 – Biotechnology

Hanno Langen studied biochemistry at the University of Zurich and received his diploma in 1984 followed by a PhD in protein design in 1988. Following his PhD Professor Langen undertook post-doctoral research at the Rockefeller University, USA from 1989 to 1990. In 1991 Professor Langen joined the Roche Center for Medical Genomics in Basel. His lab at Roche acquired its first mass spectrometer for protein characterization in 1992, even before the field became known as proteomics. In 1996 Professor Langen became head of proteomics at Roche. Since 2007 he is the global head of protein and metabolite technologies in the translational sciences at Roche.

Professor Langen was appointed honorary professor of biochemistry at the University of Basel in 2009 and he is also one of the founding members of the Human Proteome Organization (HUPO). He is also a senior editor of the journals Proteomics and Clinical Proteomics.

Professor Langen's current research is focused on the pharmaceutical and diagnostic application of proteomics in the field of biomarker discovery and validation by using high throughput protein identification workflows. He has over 80 patent applications and about 100 publications in the field of proteomics.

Cynthia Barnhart

Chair, Panel 11 – Technology for the Built Environment

Cynthia Barnhart is Ford Professor of Engineering. She is associate dean of engineering for academic affairs, professor of civil and environmental engineering and engineering systems, and director of the initiative Transportation@MIT.

Professor Barnhart's teaching and research interests involve the development of optimization methods for large-scale transportation and logistics problems. Her approaches often require the development of new models and algorithms, and their implementations in real operating environments. Her research interests include integrated schedule planning, robust scheduling and real-time re-planning.

Professor Barnhart is a member of the US National Academy of Engineering and has also served as co-director of both the Center for Transportation and Logistics and the Operations Research Center. She has served in editorial positions for Operations Research, Transportation Science, and Management Science, as president of both the INFORMS Women in Operations Research/ Management Science Forum and the INFORMS Transportation Science and Logistics Society, and as the liaison between the INFORMS Transportation Science Section and the INFORMS Aviation Applications Special Interest Group. Professor Barnhart has been awarded the Franz Edelman Prize for Achievement in Operations and the Management Sciences, the INFORMS Award for the Best Paper in Transportation and Logistics, the Advancement of Women in Operations Research and Management Science Award, the Mitsui Faculty Development Chair, the Junior Faculty Career Award from the General Electric Foundation, and a Presidential Young Investigator Award from the National Science Foundation.

Professor Barnhart's work has been published in several books and in research journals such as Transportation Science, Operations Research, Mathematical Programming, and Annals of Operations Research. At MIT she has developed and taught courses describing models and methods for designing, planning, analyzing and operating transportation and logistics systems.

Rachelle Alterman

Chair, Panel 12 – Architecture & the Built Environment

Rachelle Alterman holds the David Azrieli Professor Chair of Architecture/Town Planning at the Technion-Israel Institute of Technology. With degrees in planning and in law from Canadian and Israeli universities, Professor Alterman specializes in cross-national comparative planning law, land use regulation and property rights. Many of her 170 academic publications are in these areas, as well as in planning theory, planning institutions, implementation, and public participation. Professor Alterman is the founding president of the International Academic Association on Planning, Law and Property Rights. She serves, or has served, on the editorial advisory Boards of the Journal of the American Planning Association, Journal of Planning Education and Research, Town Planning Review, Planning Theory and Practice, and International Journal of Law in the Built Environment. She has also been a visiting professor in leading planning schools in the USA, the Netherlands, and Japan.

In 2012, Professor Alterman was awarded an honorary membership of the Association of European Schools of Planning (AESOP), one of the finest awards in academia within the planning field. Professor Alterman has also served as a consultant to the OECD, the World Bank and the UN on cross-national transfers of best practices in planning law, land policy, and housing.

Mary Czerwinski

Chair, Panel 13 – Computer Science & Mediated Communications

Mary Czerwinski is a research area manager within the Visualization and Interaction (VIBE) research group at Microsoft Research, where she manages many diverse areas of human-computer interaction, including social computing, information visualization, CSCW, sensor-based interaction and healthcare.

Dr Czerwinski's research interests involve emotion tracking and apps for behavioural change, multitasking, interruptions, information worker task management and awareness systems for individuals and groups.

She holds a PhD in cognitive psychology with a minor in statistics from Indiana University in 1988. She has a long experience of working with research within HCI areas in communications and computer science companies such as Bell Communications, 1988-1989, Lockheed Engineering and Sciences Corporation, 1989-1990, Compaq Computer Corporation, 1990-1995, Microsoft Corporation, 1995-1997 and has been at Microsoft Research since 1997.

She has been an avid participant in the ACM SIGCHI community, sitting on the SIGCHI executive committee for the last ten years, chairing CHI 2008, UIST 2005, and was papers chair for CHI 2000 and UIST 2010, in addition to many other conference volunteer roles. Dr Czerwinski was recently awarded the ACM SIGCHI lifetime service award and was also inducted into the ACM CHI academy.

Dr Czerwinski has more than 100 publications in HCI and psychology. She is very involved in supporting academia sitting on multiple university advisory boards and doctoral student dissertation committees, in addition to belonging to the University of Washington information school (iSchool) where she holds a position as an affiliate professor.

Dieter Gollmann

Vice Chair, Panel 13 – Computer Science & Mediated Communications

Dieter Gollmann is head of department for the Institute for Security in Distributed Applications at Hamburg University of Technology (TUHH), Germany, holding this position since 2003. His current research interests relate to risk analysis and to security in cyber-physical and socio-technical systems.

Professor Gollman received his Dipl-Ing in engineering mathematics in 1979 and Dr-tech in 1984 from the University of Linz, Austria. He was a lecturer in computer science at Royal Holloway, University of London, and later a scientific assistant at the University of Karlsruhe, Germany, where he was awarded the venia legendi for computer science in 1991.

He rejoined Royal Holloway in 1990, where he was the first course director of the MSc in information security. In 1998, Professor Gollman joined Microsoft Research in Cambridge. He continued as a visiting professor with the Information Security Group at Royal Holloway and has also been an adjunct professor at the Technical University of Denmark 2005-2009.

Professor Gollmann has published widely in the area of information security. He is an editor-in-chief of the International Journal of Information Security and an associate editor of the IEEE Security & Privacy magazine.

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