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Mechanical Engineering Research in Finland 2000–2007

Evaluation Report

Academy of Finland
Research funding and expertise

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Mechanical Engineering Research in Finland 2000–2007

International Evaluation

Members of Evaluation Panel

Professor Monika Ivantysynova (Chair)
Professor Adib Becker
Professor Rajamohan Ganesan
Professor Petter Krus
Professor Lin Li
Professor Jan-Gunnar Persson
Professor Panos Tsakiropoulos

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Description

Publisher	Academy of Finland	Date August 2008
Author(s)	Members of Evaluation Panel, Editor: Dr Mikko Lensu	
Title	Mechanical Engineering Research in Finland 2000–2007. International Evaluation	
Abstract	This evaluation of mechanical engineering research in Finland has been conducted by an international expert panel consisting of Prof. Monika Ivantysynova (chair), Prof. Adib Becker, Prof. Rajamohan Ganesan, Prof. Petter Krus, Prof. Lin Li, Prof. Jan-Gunnar Persson and Prof. Panos Tsakiropoulos. The objective was to evaluate the quality of mechanical engineering research and its subfields as compared to international standards. The panel was also asked to give a critical assessment of each unit and provide recommendations for the future. The panel based its opinion on self-assessment questionnaires sent to the 31 units and on site visits to the units on 7–11 April 2008. This report presents the observations and recommendations of the panel and has three main parts. The first considers mechanical engineering research in general together with issues of quality, personnel, education, funding, infrastuctures, collaboration and societal impact. The second part considers the subfields: automation, control engineering and mechatronics; engineering design; engineering materials; production and manufacturing; applied mechanics; thermodynamics; and vehicle engineering. The third part consists of the evaluations of the units. A statistical appendix based on the unit self-assessments is also included. The panel found the traditional close connection between industry and universities as a source of both strengths and problems for mechanical engineering in Finland. The research is imbalanced to the applied and short-term side, which may have an adverse effect on the long-term viability of research as well as on the competitiveness of industry. The panel recommends various measures to create more balanced research portfolios and to increase the low publication record. Fundamental research should be supported more, especially through added resources to the basic discipline of applied mechanics, and organised in a more focused manner. The units should collaborate more widely with other research areas. The PhD training was a serious concern and the panel recommends more controlled PhD programmes. The graduate school system was seen as very successful and more funding should be channelled through it. PhD studies should also have high priority in mechanical engineering units and be given more credit by the industry. The personnel policies were also of concern: more motivating career paths should be created and the workload should be reasonable and more balanced towards research. The panel found several strong areas and units, but others were under critical size and with overlapping activities. These would benefit from merging, collaboration and networking. To secure future survival the panel generally recommends more collaboration internationally and more active exploring of new research areas. This is also vital to the Finnish mechanical engineering industry which needs to explore new fields and new directions to decrease its reliance on traditional fields.	
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Julkaisun nimi	Mechanical Engineering Research in Finland 2000–2007. International Evaluation	
Tiivistelmä	Kansainvälinen asiantuntijapaneeli on arvioinut Suomen konetekniikan tutkimuksen tason. Panelin jäsenet olivat prof. Monika Ivantysynova (puheenjohtaja), prof. Adib Becker, prof. Rajamohan Ganesan, prof. Petter Krus, prof. Lin Li, prof. Jan-Gunnar Persson, sekä prof. Panos Tsakiropoulos. Konetekniikan ja sen osa-alueiden tutkimuksen laatua verrattiin kansainväliseen tasoon. Paneelia pyydettiin myös arvioimaan kukin tutkimusyksikkö (kaikkiaan 31) sekä antamaan suosituksia toimenpiteistä. Paneelin mielipide pohjautui yksiköiden itsearviointeihin sekä yksikkövierailuihin, jotka tehtiin 7–11 huhtikuuta 2008. Raportti sisältää paneelin havainnot ja suositukset ja siinä on kolme pääosiota. Ensimmäisessä tarkastellaan konetekniikan alaa kokonaisuudesaan ja käsitellään tutkimuksen laatuun, henkilöstöön, koulutukseen, rahoitukseen, infrastruktuuriin, yhteistyöhön ja yhteiskunnalliseen merkitykseen liittyviä kysymyksiä. Toinen käsittelee osa-alueita: automaatiota; kontrollitekniikkaa ja mekatroniikkaa; koneensuunnittelua; materiaalitiedettä; tuotanto- ja valmistustekniikkaa; sovellettua mekaniikkaa; termodynamiikkaa; ja kuljetusvälinetekniikkaa. Kolmannessa osiossa tarkastellaan arvioinnissa mukana olleita yksiköitä. Raportin lopussa on itsearviointeihin perustuva tilastoliite. Paneeli katsoo, että Suomen konetekniikan alalla perinteinen läheinen yhdysside yliopistojen ja teollisuuden välillä johtaa sekä vahvuuksiin että ongelmiin. Tutkimuksessa korostuvat sovellettavuus ja lyhyen aikavälin tavoitteet, millä voi pitkällä aikavälillä olla negatiivinen vaikutus sekä yksiköiden menestykseen että teollisuuden kilpailukykyyn. Paneeli suosittaa erilaisia toimenpiteitä tutkimusprofiilin tasapainottamiseksi ja julkaisuaktiivisuuden lisäämiseksi. Perustutkimusta tulisi tukea, etenkin alan perustietämykseen kuuluvan sovelletun mekaniikan kohdalla, ja hajallaan olevaa perustutkimusta keskittää. Yksiköitä hyödyttäisi laajempi yhteistyö toisten tutkimusalueiden kanssa. Paneeli oli huolestunut tohtorikoulutuksen tilasta ja suositteli järjestelmällisempiä koulutusohjelmia. Tutkijakoulut nähtiin toimivana ratkaisuna ja enemmän rahoitusta tulisi kanavoida niiden kautta. Tohtoriopintojen arvostusta tulisi lisätä sekä konetekniikan tutkimusyksiköissä että teollisuudessa. Myös henkilöstöpolitiikkaa tulisi parantaa. Tutkijoille tulisi luoda kannustavia mahdollisuuksia urakehitykseen. Työn määrän tulisi olla kohtuullinen ja jakautua järkevästi tutkimuksen ja muun työn kesken. Paneeli havaitsi vahvoja tutkimusalueita ja yksiköitä, mutta monet yksiköt olivat liian pieniä ja niiden tutkimusalueet päällekkäisiä. Tilannetta voitaisiin parantaa yhdistämällä yksiköitä ja lisäämällä yhteistyötä. Tulevan positiivisen kehityksen varmistamiseksi paneeli suosittaa kansainvälisen yhteistyön lisäämistä ja rohkeampaa hakeutumista uusille tutkimusalueille. Tämä on myös elintärkeää Suomen metalli- ja koneteollisuudelle, jonka tulisi vähentää riippuvuuttaan perinteisistä aloista etsimällä uusia aluevaltauksia ja kehityssuuntia.	
Asiasanat	Konetekniikka, tutkimuspolitiikka, tutkimuksen rahoitus, arviointi, kontrollitekniikka, koneensuunnittelu, materiaalitekniikka, tutotantotekniikka, sovellettu mekaniikka, kuljetusvälinetekniikka	
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Preface

Mechanical engineering is strategically important to the future of Finnish society, business and industry. In 2006, the total turnover of the metals and mechanical engineering industry in Finland was 38 billion euros, or 30 per cent of total industrial output, and the export value was 23 billion euros, one third of total exports. The number of employees was 153,000, 25 per cent of all industrial employees. R&D investment of companies in the industry stood at 445 million euros, representing 1.2 per cent of the turnover, and public research investment in universities and research institutes amounted to 39 million euros. The total investment in research represented about 4,000 research employees' annual R&D input.

To provide background information for the research policies in this field the Academy of Finland Research Council for Natural Sciences and Engineering decided to conduct an international evaluation of mechanical engineering research in Finland. The evaluation targets public research investment in the field and covers relevant research carried out at universities and research institutes during 2000–2007. In September 2007, the Council appointed a steering group to supervise the evaluation process. It was chaired by Professor Jarmo Partanen from Lappeenranta University of Technology. The other members were Technology Manager Timo Laurila from Tekes, the Finnish Funding Agency for Technology and Innovation, Director Ilkka Niemelä from the Federation of Finnish Technology Industries, Research Professor Tuija Pulkkinen from the Finnish Meteorological Institute, and General Manager Pirjo Virtanen from Metso Minerals. Professor Partanen and Professor Pulkkinen are also members of the Research Council for Natural Sciences and Engineering. The Steering Group held its first meeting on 24 October 2007 and appointed Dr Mikko Lensu as the scientific coordinator of the evaluation. On behalf of the Academy of Finland, the process was managed by Science Adviser Vesa Siivola, who was backed by Susan Linko, Director of the Natural Sciences and Engineering Research Unit, and assisted by Project Officer Suvi Vilkki.

To define the scope of the evaluation a short questionnaire on research profile was sent to potential units. Based on the responses, 31 units were selected by the Steering Group: 16 units from Helsinki University of Technology (TKK), three units from Lappeenranta University of Technology (LUT), five units from Tampere University of Technology (TUT), six units from the University of Oulu (UO), as well as the Industrial Systems Knowledge Cluster of VTT Technical Research Centre of Finland. In 2006 the total funding of these units was about 80 million euros, of which 85 per cent targets the fields of the evaluation, and the total number of research personnel was about 800. About 3,000 MSc degrees and 200 doctoral degrees were obtained from the units during the evaluation period 2000–2007.

For the collecting of data for evaluation purposes, a self-assessment form was sent to the units at the end of 2007 (Appendix D). The form requested basic quantitative data from the evaluation period: personnel resources, funding, research output and education. The units were also asked to describe their research activities and strategies, together with national and international collaboration, and provide a detailed self-assessment with a SWOT analysis. This data has been used in the statistics part of this report (Appendix A).

The Steering Group convened an international expert panel, which was appointed by the President of the Academy of Finland to carry out the evaluation. The evaluation panel was chaired by Professor Monika Ivantysynova from Purdue University, USA, and the other members were Professor Adib Becker from the University of Nottingham, UK, Professor Rajamohan Ganesan from Concordia University, Canada, Professor Petter Krus from Linköping University, Sweden, Professor Lin Li from the University of Manchester, UK, Professor Jan-Gunnar Persson from the Royal Institute of Technology, Sweden, and Professor Panos Tsakiropoulos from the University of Sheffield, UK. The personal profiles of the panel members are available in Appendix B.

The objective, as defined to the panel, was to evaluate the quality and relevance of mechanical engineering research in Finland during 2000–2007 as compared to international standards. The panel was asked to consider the field as a whole, together with its subfields, and to give a critical assessment of each unit. Recommendations for future development of the research were requested as well. These guidelines are given in more detail in the Terms of Reference (Appendix C). The panel based its opinion on preliminary material, especially the submission forms, and on site visits made during 7–11 April 2008. The visits had a typical duration of 1–1.5 hours and consisted of a short introductory presentation by the unit followed by a discussion between panel members and unit representatives.

Executive summary

The Academy of Finland invited an international panel of experts to evaluate the scientific quality of mechanical engineering research in Finland in 2000–2007. The panel was asked to assess mechanical engineering research as a whole as well as the different subfields of mechanical engineering and individual research units. This report presents the observations, findings and recommendations of the evaluation panel.

The main recommendations of the panel are as follows:

1. The panel was generally impressed with the units' close cooperation and number of connections with industry. However, the nature of this relationship needs to be changed. The collaboration with industry should be conducted in a manner so that research results can be published quickly in journals and at conferences.
2. The units need to find a balance between basic and applied research. At present, too much time and funds are spent on applied research and responding to the short-term needs of industry. In order to focus more on fundamental research, it may be necessary to reconstruct how research funds are allocated.
3. The graduate school system of the Academy of Finland is seen as a very successful initiative. Therefore, a larger portion of funds should be channelled through graduate schools.
4. A more controlled program for completing the PhD should be implemented. PhD students should be guaranteed to do research at a level of about 80 per cent of their time. They should also have a structured plan from the beginning of their programme for 4–5 year completion. This plan should be updated and revised on a regular basis, and appropriate action should be taken at the departmental level if deviations from the plan become excessive.
5. Research groups should annually review their research output against an international scale, and promptly address any shortcomings in the number of journal publications and PhD completions.
6. Universities should have entry-level, mid-career-level and established-level academic positions, for example assistant professor, associate professor and full professor positions, as in the North-American system. In addition, they should have more appropriately titled engineering staff, for example research assistants and research associates, depending on their qualifications and experience.
7. There should be an increased number of researchers in the fields of applied mechanics, aeronautics, automotive engineering and thermodynamics. In addition, some small units should merge in order to become more productive.
8. More collaboration with physics, chemistry, computing, biology and energy research groups is encouraged to enable deeper understanding of basic phenomena and open new technology and science development opportunities.

9. In order to avoid overlapping research activities and to create interaction between units it would be beneficial to start strategic networking and reorganisation of research within the same university in similar and related disciplines in order to compete internationally.
10. The units need to explore new areas of research that are becoming increasingly important internationally.

1 Introduction

1.1 Panel members

Monika Ivantysynova is Professor of Agricultural and Biological Engineering and Mechanical Engineering at Purdue University, West Lafayette, USA. She is the director of the MAHA Fluid Power Lab at the university.

Adib Becker is Professor of Mechanical Engineering at the School of Mechanical, Materials and Manufacturing Engineering, University of Nottingham, UK, and Head of the Structural Integrity and Dynamics Research Group.

Rajamohan Ganesan is Professor at the Department of Mechanical and Industrial Engineering at Concordia University, Montreal.

Petter Krus is Professor in Machine Design at the Department of Management and Engineering, Linköping University, Sweden, and Head of the Division of Machine Design.

Lin Li is Professor of Laser Engineering at the School of Mechanical, Aerospace and Civil Engineering, University of Manchester, UK, and Director of the Laser Processing Research Centre.

Jan-Gunnar Persson is Professor of Machine Design at the Department of Machine Design, Royal Institute of Technology (KTH), Stockholm, Sweden.

Panos Tsakiropoulos is Professor of Metallurgy and POSCO Chair in Iron and Steel Technology at the Department of Engineering Materials, University of Sheffield, and Director of IMMPETUS (Institute for Microstructural and Mechanical Process Engineering: University of Sheffield).

The detailed personal profiles of the panel members are available in Appendix B.

1.2 Background of the evaluation

The Academy of Finland Research Council for Natural Sciences and Engineering decided in 2007 to conduct an international evaluation of mechanical engineering research in Finland. The Research Council appointed a steering group, chaired by Professor Jarmo Partanen, to supervise the execution of the evaluation. The Steering Group convened an international expert panel, which was appointed by the President of the Academy of Finland to carry out the evaluation. The evaluation targeted public research investment in the field and covered relevant research at universities and research institutes during 2000–2007. This report contains the observations and recommendations of the panel.

The principal aim was to survey the quality of Finnish mechanical engineering research by comparing it to international standards and practices. The general background motivation was the strategic importance of the field to Finland and the benefit that future research policies and programmes would gain from the evaluation. The Research Council also wished to view the impact of Academy of Finland funding in the field and get information on how the Academy's funding instruments can be improved and how the resources can be optimally targeted. This concerned especially the impact of graduate schools, the funding of which is administered and in part covered by the Academy, the Centre of Excellence programmes, which are principally funded by the Academy, as well as the Research Programme for Future Mechanical Engineering (TUKEVA 2000–2003) of the total funding of which (€4.25m) the Academy covered 3.53 million euros.

The evaluation was also in other respects timely. Helsinki University of Technology (TKK) and Tampere University of Technology (TUT) restructured their organisations to a faculty/department model, which were launched at the beginning of 2008. At Lappeenranta University of Technology (LUT), a similar change had occurred in 2007. Further changes are due in future. This evaluation is expected to be beneficial to the restructured units and organisations when they create their long-term strategies. It also provides a reference for future evaluations, making possible the assessment of the effectiveness of the new strategies.

Future expectations also rise from MeKo-SHOK, the Strategic Centre for Metal Products and Mechanical Engineering. It is one of the Strategic Centres for Science, Technology and Innovation (CSTIs, in Finnish SHOKs) established through the initiative of the Science and Technology Policy Council of Finland. They are independent cooperative bodies that aim at more integrated innovation chains combining basic and applied research, as well as at strategic mid- and long-term planning respecting end-application needs within a 5–10-year time frame. The preparatory work for CSTIs is coordinated jointly by Tekes and the Academy of Finland. After the preparatory phase, companies, universities and research institutes agree a joint research programme and administrative arrangements for each centre. The favoured solution is to arrange a CSTI as a company where the different actors participate as stakeholders. The CSTIs, which are planned to be five in number, are presently turning into an operational phase. MeKo-SHOK was launched in April 2008 and structured as an innovation company, Fimecc Ltd (Finnish Metals and Engineering Competence Cluster).

1.3 Terms of reference

The objective of the evaluation, as defined to the expert panel, was to evaluate the quality and relevance of mechanical engineering research in Finland in 2000–2007 as compared to international standards. The panel was asked to consider the field as a whole, together with its subfields, and to give a critical assessment of each unit. Recommendations for future development of the research were requested as well. Besides scientific quality, important issues included personnel and career policies, researcher training, adequacy of resources and research networking. These are given in more detail in the Terms of Reference (Appendix C).

1.4 Evaluation process

The Steering Group identified 31 units conducting substantial and relevant research in the mechanical engineering field. For the collecting of data for evaluation purposes, a self-assessment form was sent to the units at the end of 2007 (Appendix D). Based on the returned forms, a summary report was compiled by the Academy of Finland and this data has also been used in the statistics part of this report (Appendix A).

The panel based its opinion on the forms, the summary report, other preliminary material and on site visits to all units made during 7–11 April 2008. The visits had a typical duration of 1–1.5 hours and consisted of a short introductory presentation by the unit followed by a discussion between panel members and unit representatives. At least three panel members were present during each visit. After the visit the panel had a short session for collecting the observations and opinions.

1.5 Notes on terminology and style

(i) This report presents the perceptions of the international panel about mechanical engineering research in Finland in 2000–2007. In the introductory sections and appendices the panel has been assisted by the editor and the Academy of Finland, otherwise the panel as a whole is responsible for the text. However, various parts of the report were initially contributed by different panel members, resulting in variations in style that may be visible in the report. In general, the length of the discussion in different parts of the report should not be interpreted to reflect the scientific quality of the discussed subfield or unit of research. Naturally, some observations gave rise to more discussion in the panel than others.

(ii) The host organisations are abbreviated as follows:

TKK	Helsinki University of Technology
LUT	Lappeenranta University of Technology
TUT	Tampere University of Technology
VTT	VTT Technical Research Centre of Finland
UO	University of Oulu

The units of Helsinki University of Technology (TKK), or laboratories, refer to the old organisation of the university. Their relationship to the present organisation is explained in Appendix A, section A.2. All other units have their current names. The unit abbreviations in Appendix A are not official abbreviations and are used in this report only.

Apart from these, the report includes the following abbreviations:

CAD	Computer Aided Design
FTE	Full Time Equivalent
IT, ICT	Information (and Communication) Technologies
IPR	Intellectual Property Rights
SME	Small and Medium-sized Enterprises
Tekes	Finnish Funding Agency for Technology and Innovation

2 General recommendations

2.1 Profile of mechanical engineering research in Finland

Sustained publicly funded mechanical engineering research in Finland is carried out at VTT Technical Research Centre of Finland and at four universities: Helsinki University of Technology (TKK), Lappeenranta University of Technology (LUT), Tampere University of Technology (TUT) and the University of Oulu (UO). In 2006, the total funding of the 31 units in this report was about 80 million euros, of which 85 per cent targets the fields of the evaluation, and the total number of research personnel was about 800. During the evaluation period 2000–2007 the output of the research amounted to about 4,000 articles published in refereed scientific journals and conference proceedings and to more than 100 patents. About 3,000 MSc degrees and more than 200 doctoral degrees were obtained in the units during the same period.

Mechanical engineering research in Finland includes research within the following fields: automation and control, mechatronics, engineering design, engineering materials, metallurgy, production and manufacturing, applied mechanics and vehicle engineering. However, in some of these fields, there is also research that cannot be counted as mechanical engineering or closely related to it. This research is not considered here.

There is a substantial amount of mechanical engineering research in automation and control. Also, the number and size of the units in production and manufacturing and engineering design seems appropriate. Relevant areas of materials engineering are addressed by many units and the groups are comparable in size to groups in other countries. However, there are very few groups working in the field of applied mechanics, and this area seems to be underrepresented. The teaching load of the applied mechanics groups compared to the size of some units seems to be too high, so there is limited opportunity for research in these units. Other than a small group in combustion engines, there is very little research activity in thermodynamics within mechanical engineering. Within vehicle engineering, the size and the profile of the ship building unit are comparable to units in other countries while the other subfields like automotive engineering and aeronautics are underrepresented.

The structure and proportion of resources within disciplines of mechanical engineering in Finland reflect the historical Finnish industrial structure. For the most part, the conducted research is of an applied nature that is reactive to the short-term needs of Finnish industry. This creates an imbalance between applied and basic research. It seems that the units have difficulties exploring research in emerging fields that are becoming increasingly important internationally.

Overall, research within the subfields of mechanical engineering in Finland is somewhat imbalanced. Some areas such as engineering materials and production and manufacturing are well represented while areas such as fluid mechanics and thermodynamics are not.

2.2 Quality of research output

In line with international standards the research output can be measured by a combination of several indicators. These indicators include publications in high-quality refereed journals and the number of PhD degrees awarded, patents and spin-off companies. Ultimately, the quality of the research output is determined by its impact on the international scientific community as well as on the Finnish economy.

There is clear evidence that the research in many of the visited mechanical engineering units is of a world-class quality and has international visibility, although this is not always reflected by the abovementioned indicators. In general, compared to similar research groups in other countries, the number of publications in peer-reviewed journals is relatively low. However, the panel has reviewed publications submitted by the units, and was generally satisfied with the quality of the work presented.

Many units did not recognise the need of journal publications as a high priority. As a result, some of their selected best publications were chosen from conference proceedings. In some units, the number of conference publications far exceeded the number of journal publications. Another reason for the low number of journal publications could be the confidential nature of industrially funded research projects.

Also, the number of PhD thesis completions is relatively low compared to international standards. There is evidence of strong experimental research activities and facilities that are crucial to these activities. However, well-balanced experimental and theoretical research is needed. The panel noted that there are many unexploited areas in which experimental work could be linked to fundamental theory. With the addition of more theoretical research there is an increased probability of carrying out world-class research resulting in high-quality journal publications.

The panel recommends that research groups annually review their research output against an international scale, and promptly address any shortcomings in the number of journal publications and PhD completions. University management need to develop and put in place performance indicators for scientific output that recognise, encourage and support peer-reviewed journal publications and PhD training.

2.3 Research personnel

In order to establish and sustain a strong discipline such as mechanical engineering research personnel must possess strong leadership, motivation, vision and strategy. The panel observes that many of the units possess these attributes. The few units that need to improve have been identified in the section on individual units.

The number of research personnel in most subfields of mechanical engineering is appropriate relative to the size of the country. However, the number of researchers in the areas of applied mechanics, thermodynamics, aeronautics and automotive engineering is exceptionally low. In particular, the number of researchers in the areas of aeronautics and automotive engineering is not adequate to represent the field successfully at an international level.

There is a lack of career planning and development strategy among the researchers of all areas of mechanical engineering. In the academic structure of universities, there is no promotion and career development policy in place. In order to stimulate and foster continuous career development, universities typically have entry-level, mid-career level, and established-level academic positions, for example assistant professor, associate professor and full professor positions as in the North-American system. This system would encourage researchers to develop a career path based on a sustained pattern of high-quality research. This would also enable systematic development of research leadership through adequate training and acquisition of experience and expertise. The panel recommends that such a system or a similar system be established at Finnish universities.

The proportion of international researchers coming to various units of Finnish universities is low; especially for researchers outside of EU. This situation should be corrected by creating a number of visiting fellowships and professorships. The number of senior research personnel without a PhD degree is high relative to international standards. The direct consequence of this is that the situation does not foster an academic culture where the PhD degree is appreciated and recognised as an important step in research career development. Therefore, a stringent requirement to hire PhD graduates for senior research positions should be enforced and incentives for non-PhD researchers to take up and complete PhD degrees should be provided.

Engineering staff should be more appropriately titled, for example as research assistants and research associates, depending on their qualifications and experience. These kinds of position titles are used in universities in other countries. Also, this would encourage and motivate researchers to upgrade their qualifications and background, as well as reward them for their accomplishments and achievements.

Another important aspect is a balanced workload. A system should be established that balances the workload from teaching, research and administration. Researchers, especially professors, should be able to spend adequate time and efforts on research activities, instead of being overwhelmed and exhausted by teaching and administrative work.

In the present knowledge-based society, the issue of intellectual property rights (IPR) needs more careful attention, given the high involvement of units in industry-led projects. Collaboration with industry should be conducted in such a manner that the research results can be published quickly in journals and conferences. This will bring the research groups of the units the required visibility and recognition among the international community, thereby raising the research profile of the mechanical engineering field.

2.4 Researcher training

As previously stated, the number of PhD students in the mechanical engineering field in Finland is relatively low. One of the reasons for this situation may be that the PhD degree is not sufficiently recognised by industry, and even more seriously, not by universities. In addition, the time taken to complete the PhD and submit a thesis is much longer than the expected four years. This may be due to the fact that a majority of mechanical engineering PhD students are funded from industrial projects for only short periods at a time and therefore adequate continuous funding for thesis completion is often not available. Many units are so dependent on industrial projects for their survival that involvement in these projects gives more prestige than progress in PhD studies. These conditions create an atmosphere where PhD research does not have priority. This is augmented by the fact that many senior staff members do not have a PhD degree themselves. Also, due to a lack of funding, many PhD students leave their university posts with no intention of completing their PhD programmes, because of more financially rewarding and structured career paths available in industry.

In many cases, the significant dependence on industrial projects has a detrimental effect on scientific output. This is partly because universities get involved in pure R&D projects that do not provide opportunity for scientific contribution. Furthermore, even if the project yields scientific results, these cannot be published for reasons of confidentiality.

There are, however, positive examples from some units that have actively fostered a relationship with industry, where the need for scientific output is understood by industry. It should be emphasised that relevant industrial projects are important for high-level research in applied research areas. Therefore, developing a healthy relationship to industry should be a high priority.

There are also positive examples of PhD students that have produced a PhD thesis in an acceptable time frame. These students are personally motivated and supported by their supervisor. The graduate school system coordinated by the Academy of Finland must be seen as a very successful initiative. In all of the evaluated units with an established graduate school, the PhD students seemed to be on track and very dedicated towards completing their degree. This indicates that graduate schools have a very important role. A larger portion of funds should be channelled through the graduate schools.

Another action to be considered is a more structured programme for completing the PhD. As is implemented elsewhere, students in PhD programmes should be guaranteed an opportunity to do research at a level of at least 80 per cent of their time. They should also have a structured plan from the beginning of their programme for 4–5-year completion. This plan should be updated and revised on a regular basis, and appropriate action should be taken at the departmental level if deviations from the plan become excessive.

2.5 Research funding and infrastructures

The state of the research funding and infrastructure of all evaluated units is of very serious concern. The funding that was provided by the Academy of Finland and Tekes over the period of the evaluation (2000–2007) would not be able to sustain mechanical engineering research in Finnish academic institutions in the long term. It is recommended that funding agencies (e.g. the Academy and Tekes) establish procedures and mechanisms to ensure that research in this field could be sustained in Finland in the long term.

Basic research was almost non-existent in most places and the emphasis on applied research was overwhelming. In a few extreme cases, the emphasis on plain services to industry indicated that the groups were admitting that they had run out of ideas and that their future existence would be threatened if industry were not to ask them to solve some of its short-term problems. Staff at the evaluated units implied that funding agencies and industry tend to view only research that can be applied in the short term to have value. It is recommended that funding agencies (e.g. the Academy and Tekes) reconsider how funds are allocated for research and seek to value and reward fundamental and applied long-term research.

The existing structures of some universities have kept certain closely related activities in different cost centres and in other universities the restructurings have failed to bring them together. The panel is seriously concerned that this might hinder the ability of departments to build up their portfolio of basic and fundamental research and to balance it with their applied research and services to industry work. If they cannot accomplish this, and thereby enhance their national and international standing, it will threaten the very activities that are key to the future of mechanical engineering research in Finland. It is recommended that future funding opportunities could challenge such structures and if required even demand restructuring prior to the release of funds.

The panel is concerned about the small size of certain teams in the field of applied mechanics. It is recommended to fund research posts (e.g. research chairs) with further support (fully funded PhD studentships) to strengthen these research groups.

The nature of the facilities required for mechanical engineering research often makes them difficult to purchase and maintain in the long run. The Academy of Finland or the Finnish Government should provide funds to update and maintain these important establishments as well as provide funds to build new research laboratories for conducting experiments. It is also recommended that the units have access to materials processing, which would support advanced manufacturing research, access to mechanical and other testing and access to materials characterisation facilities, and that researchers be supported in the use of such facilities.

There is also a supercomputing centre, the Finnish IT Centre for Science CSC, with easily accessible services. It is recommended that the units more actively utilise the supercomputing potential in advanced modelling. The panel also recommends the generous support of the Centre of Advanced Steel Research CASR at the University of Oulu and the funding of Finnish groups to network with CASR.

2.6 Research collaboration

Mechanical engineering research groups in Finland have strong collaboration with Finnish industry and EU partners (both industrial and academic), with most research projects involving industrial partners. Sustained industrial and EU collaboration is also driven by the need to obtain funding from Tekes and EU framework programmes in order to support research activities. There is good collaboration with researchers and research teams from non-EU countries mainly through staff/student exchange and mutual visits. There are also excellent examples of collaboration between different universities, as well as departments within the same university. However, in some units, there is evidence of overlapping research activities with little or no interaction between the research groups.

In addition, the panel recommends more collaboration with physics, chemistry, computing, biology and energy research groups to foster deeper understanding of basic phenomena and to open up new technology and science development opportunities. This is especially important to basic mechanical engineering disciplines such as solid mechanics, fluid mechanics, materials science and thermodynamics.

The panel has come across several small units that lack critical mass. These units would greatly benefit from merging with other groups to complement their research and develop new lines of collaborative research.

In this regard, the panel recommends establishing strategic networking between new and established units on a national as well as an international level.

2.7 Societal impact

Mechanical engineering research in Finland is mostly of an applied nature and to a large extent driven by the current needs of industry. This has long been a tradition in Finland. Strong industrial cooperation is definitely a strength characterising Finnish research in the field. Teaching is also much related to industry, with industrial training of Master's students in most cases carrying out their theses within industrial projects. Finnish mechanical engineering research – and particularly education – therefore has a strong societal impact. Industry and, hence, Finnish society gain benefits from this collaboration and many new products have been commercialised worldwide.

However, the short-term perspective is obvious. The panel recommends a more balanced project portfolio containing also basic, long-term and visionary research besides applied research catering current industry needs. It is strongly recommended that the units initiate and carry out more long-term and basic research to generate new innovations and to implement new technologies to enhance the long-term competitiveness of Finnish industry. In particular basic research to support energy, environment, sustainability and safety issues is recommended, as these topics will be of major importance in future and are open for many areas of research within mechanical engineering.

PhD training is one important mechanism with which to enhance knowledge and innovative capability in industry. Hence, it is of importance to industry competitiveness and to the well-being and development of society in future. The panel therefore recommends the strengthening of PhD training by increased long-term funding (e.g. from the Academy of Finland) and graduate schools, as well as by stimulating industry to recruit PhDs.

Increased international researcher mobility is also recommended. It is considered by the panel to be very important in stimulating innovative research within new fields in Finland – with positive effects for Finnish society.

Indirectly, the application-based organisational structure within mechanical engineering at Finnish universities, with research in basic disciplines scattered over units as fragments subordinated to applied research, entails a risk of weakening competitive power in future, that is, that long-term social impact will suffer.

3 Evaluation of subfields

3.1 Automation, control engineering and mechatronics

Research activities in automation, control engineering and mechatronics are carried out by several of the visited units (14 out of 31 reported activities in this area). The strongest contributions in machine automation and control are from the Helsinki University of Technology (TKK) Automation Technology Laboratory and the Tampere University of Technology (TUT) Department of Intelligent Hydraulics and Automation. Both groups are renown and their contribution to the field of machine automation and robotics is remarkable and of world class. The establishment of the Centre of Excellence in Generic Intelligent Machines Research (GIM) by the Academy of Finland in January 2008, where both units will work together in "Future Worksite" concepts, will help strengthen and expand this research field in Finland and ensure the country's leading position in some of the subfields of machine automation.

Substantial work in mechatronics, especially in modelling and simulation of complex non-linear machine systems with flexible structures, large-scale robots and intelligent machines, is performed by the Lappeenranta University of Technology (LUT) Laboratory of Mechatronics and Virtual Engineering. The Mechatronics and Machine Diagnostics Laboratory at the University of Oulu (UO) conducts research in model-based control of intelligent materials and structures, active vibration control and in the field of surgical robots. With the two large groups forming GIM and the two smaller units at LUT and UO, the field of machine automation, control engineering and mechatronics forms the strongest research area within Finnish mechanical engineering.

3.2 Engineering design

In many of the assessed units in Finland, engineering design features as a common theme throughout their teaching and research. Engineering design is, by nature, a multidisciplinary field that traditionally has combined several subfields, such as solid mechanics, dynamics, thermodynamics, fluid mechanics, materials, manufacturing and computer simulation. The focus of many of the design projects in the units is on manufacturing, ship engineering and automotive engineering applications. Design research in the visited units is mainly funded by industry, with a small proportion of funding from the Academy of Finland.

The panel was generally impressed with the experimental facilities available for research into engineering design and the excellent teaching facilities dedicated to design. Undergraduate engineering students undoubtedly receive a first-class design education and derive considerable benefit from interaction with industry.

There is evidence of many examples of direct commercial benefit to industry, since many funded design research projects lead to better industrial practices and improved designs. However, this is difficult to quantify. This has also led to continued funding from industry for many research units, which reinforces the successful outcome of the university-industry relationship and the applied nature of the research work.

However, without long-term investment in fundamental development in solid mechanics, thermofluids and materials science, there is a serious risk that the design, mechanics of materials and composites research units in Finland will not produce high-quality, internationally leading research in this field and will end up being driven by the needs of industry, rather than being proactive and creative in innovative design research.

As a result of the dependency on direct funding from industry, PhD students in engineering design often receive only partial funding for their PhDs and consequently take too long to complete their degrees, judging by international standards.

Publications on engineering design tend not to feature highly in journals, and in general do not result in high citation counts. The main outlet for publications in engineering design is in conference publications, which are often not rigorously refereed. The panel has noted that, on an international scale, the number of journal publications in this field is small, resulting in limited international visibility for the research units. The panel recommends that design units develop a strategy for enhancing conference papers to convert them into journal publications.

The panel also recommends that engineering design units establish a policy of long-term integration of design engineering with other disciplines, particularly in solid mechanics, thermofluids and materials science and engineering at the same university or nationally. This can be achieved by a series of interactive design workshops and seminars to encourage academic staff to develop more collaboration with other engineering academics. The Academy of Finland should consider funding the initial phase of these interactions, and subsequently invite competitive bids for funding full-time PhD students in innovative projects that combine design with fundamental developments.

3.3 Engineering materials

Engineering materials are addressed by many units and not only by those specifically linked to materials in their titles. The evaluated units have disproportionately strong dependence on industrial funding. The units should realise that industrial short-term work with the materials theme, as distinct from more fundamental research in engineering materials, is not sufficient to justify their existence as academic units, not to speak of achieving world-class standing. It is recommended that the units aim to engage with fundamental research and keep this distinct from the excessive volume of work that can be appropriately described as services to industry. Such work is indeed crucial for the short-term survival of the units, but does endanger the long-term academic viability for a significant number of them and does also have an adverse effect on staff morale.

The size of some of the evaluated units is sub-critical and there are also senior staff completely disengaged from research. Almost in all units, staff work close to exhaustion. The age profile is alarming, academic promotion and career opportunities for staff who would elsewhere be promoted to personal chairs are non-existent, and university policies for replacing staff and filling vacant posts are most worrying. It is recommended that the units be assisted by funding agencies (e.g. the Academy and Tekes) and host universities to reach and maintain critical size, that universities establish procedures for staff promotions and replacement and that this be monitored by funding agencies, and that funding agencies as a matter of priority establish nationally agreed career paths for active research staff and set active engagement of all senior staff as a prerequisite for the release of funds.

Steel is the material of choice owing to funding opportunities created by Tekes and offered by industry. Disappointingly, steel-based research receives extremely modest funding by the Academy of Finland. Given the importance of ferrous/steel metallurgy to the Finnish economy, the formation of the Centre of Advanced Steel Research CASR at the University of Oulu is most welcome. It is recommended that funding by the Academy for steel-based research be increased and that steel research at the CASR be generously supported by the Academy and Tekes. Non-ferrous materials (e.g. copper-based) are also addressed as well as metal-matrix composites and functional materials. There is also expertise in microstructural characterisation and modelling. The latter is too applied and not driven to address fundamental issues. Some units have potential for expansion in new material types or new areas of research, but even in these cases the approach to starting something new is strongly conservative. It seems to be masked by an inherent fear of long-term viability and the danger of engaging in something that might not have short-term industrial relevance and bring in the much needed funds.

Performance indicators of units engaging in engineering materials are in most cases significantly better compared with other units and follow the trend for metallurgy or materials science and engineering departments outside Finland. This is particularly true for steel-based research. It is recommended that materials engineering be encouraged to expand to cover a wider range of material types.

Pockets of research excellence do exist among the units, mainly in ferrous metallurgy/steels, but even these are in serious danger of irreversible loss of their international visibility earned in the 1980s and 1990s, owing (a) to the structure of public sector funding of engineering materials research, (b) to the challenges posed by financing and academic structures of universities, and (c) to their current research portfolios, having an overwhelming emphasis on short-term goals overdetermined by issues of financing, staff age profile and facility maintenance; lacking vision and mechanisms to advance a research culture that could foster innovation; shying away from other (non-ferrous) materials that could open up areas of new research; and being devoid of ambition for basic fundamental research and strategic platform research.

3.4 Production and manufacturing

Production and manufacturing of mechanical products in the Finnish metals and mechanical engineering industries represent an important and substantial part of Finnish industries' output. Research within this field is of strategic importance to Finland and research in this area is carried out at all of the evaluated sites: HUT, TUT, LUT, UO and VTT. In addition to the units entitled ‘Production’ or ‘Manufacturing’, production-related research is also included partially in some other units, such as TKK units 5 and 11 in this evaluation and many material science and engineering groups.

Research activities at the different sites are to some extent complementary to each other and the units often cooperate to strengthen their total impact and to avoid too much overlapping. As Tampere is located in the gravity centre of the Finnish manufacturing industry, the TUT Department of Production Engineering is the largest unit. Also the production research group, with activities in laser processes and functional coatings, within the VTT Industrial Systems Knowledge Cluster is located in Tampere. At the TUT Department of Production Engineering, also product development and design has been integrated, to cover the entire chain from CAD models and PDM/PLM (Product Data/Lifecycle Management), modularisation of products and production systems, preproduction engineering/process planning, tooling, manufacturing and quality assurance. There is also strong research activity within LUT in production and manufacturing, with particular focus on laser processing as part of the joint LUT/VTT Laser Processing Centre. Many of the units also address IT support and automation of manufacturing and assembly. Some aspects of production research are well integrated into materials science and engineering as at TKK and UO, with activities including welding, forming, forging, casting and heat treatment. Many research results have been applied and commercialised by Finnish industries and some of them are even used in other countries.

Production research in Finland is mostly of an applied nature, relevant to heavy industries such as large land vehicles, ships and paper/wood production machines, driven by the current needs of the manufacturing industry. This has long been a tradition in Finland. This is also related to the fact that production research is usually funded by Tekes, with a high degree of industry participation. This strong industry cooperation is definitely a strength characterising Finnish production research, but, on the other hand, there should in addition be more basic research on fundamental topics, which could support long-term industry development and innovation.

With the strong international competition, outsourcing to South East Asian countries and possibly to other newly industrialised regions is increasing and there is a risk of closing down some of the traditional manufacturing activities in Finland. This situation has already been seen concerning the subfield tooling, where research funding and activities have been significantly reduced. Much acquiring of new technology and research is carried out in the new, rapidly growing economies, so a new research profile for Finland to stay competitive in future will be required. Automation, information technology, integration and flexibility are therefore important issues, already treated at the units in production and manufacturing. However, initiation of more free and innovative research also on new manufacturing technologies is strongly recommended by the panel, to meet the increasing energy and environmental requirements as well as micro- or nano-scale fabrication and related new sciences.

Research in production technology is also to a large extent experimental. The cost of investment, maintenance and operation of equipment is therefore considerable. It is often not possible to cover this cost within project budgets. One solution to this would be a higher degree of cooperation, between research units and with industry. A source for separate funding of expensive equipment should be favourable. Equipment such as machine tools, robots and FMS (Flexible Manufacturing System) cells will also be required for Master's student training.

3.5 Applied mechanics

The applied mechanics area forms the basis for the mechanical engineering discipline. It consists of two major subjects: solid mechanics and fluid mechanics.

Due to its pivotal and fundamental role, it is customary to have a strong group in the applied mechanics area in mechanical engineering.

Current research in the applied mechanics field in the visited mechanical engineering units is, judging by international standards, somewhat weak. In Finland, there is presently only one unit devoted to applied mechanics at TKK, and one other unit devoted to engineering mechanics at UO. At TUT and LUT, there is no unit or department dedicated to the applied mechanics area.

Among the applied mechanics units of TKK and UO, there is no visible collaboration and interaction to a level that is required of a well-balanced and well-positioned mechanical engineering discipline. This situation has resulted in direct and severe negative impacts on the development of basic research in the areas of machine design, automotive structures, ship structures, composite structures etc. The groups within applied mechanics themselves are somewhat disconnected and have not made use of the potential benefits of active collaboration with other units. There is also no appreciable enthusiasm and motivation among the researchers. This is especially valid for the TKK Laboratory of Aerodynamics (the only one in Finland).

The TKK Department of Applied Mechanics has recently been created by bringing together groups that were working in different directions in the past, which has initiated a dialogue between various groups to work together in a productive collaborative manner. However, they should proceed in high gear in such efforts if they are to achieve sufficient strength to compete with other units that have more coherency and homogeneity.

The Applied Mechanics Department is preoccupied with a heavy teaching load involving hundreds of students. They have practically no time to engage in research and to establish a critical mass to be competitive and visible at the international level.

It is very important that the universities allocate more professorships in the areas of solid mechanics and fluid mechanics, which will allow professors to share their teaching loads so they have more time for research. In addition, there is no good strategy for replacement of professors. For example, one professor of the solid mechanics group at TKK retired in 2006. A new professor was nominated in early 2008 and he will start in the autumn of 2008. At the UO Engineering Mechanics Laboratory, most of the researchers are nearing the end of their current contracts, which have not yet been renewed. The Academy of Finland should help create research chairs in the area of applied mechanics and also support more graduate school positions.

3.6 Thermodynamics

Thermodynamics research in Finland is not part of this mechanical engineering evaluation, following the organisational structure at Finnish universities. However, some of the evaluated units' research is partly within the field of thermodynamics. Furthermore, research in the related field fluid dynamics is carried out at some of the units, often as part of their applied research on combustion engines and aerodynamics, for instance. Some comments on thermodynamics are therefore motivated in this report.

Energy supply and transportation will definitely be among the most important global engineering challenges for the future. The energy field is strongly related to environmental issues such as global warming and a sustainable society. Solid fundamental knowledge will be required to develop, for example, new energy sources as well as efficient production processes, energy distribution, storage and utilisation. Research in thermodynamics is essential for the development of new innovative thermal processes and equipment, and many applications within mechanical engineering can also be foreseen.

According to international academic standards, thermodynamics is an important discipline within the field of mechanical engineering. Internationally, thermodynamics also often covers fluid dynamics (compressible flow, gas dynamics). At Finnish universities, however, the university structure is different and thermodynamics is mainly part of other faculties, in the fields of energy and chemistry. Within the units evaluated here, there are some units directed towards thermodynamics; the units in this field are primarily the Internal Combustion Engine Laboratory and the Laboratory of Aerodynamics at TKK Other units partly in the field of thermodynamics are the TKK Laboratory for Mechanics of Materials, in this case directed to solid mechanics and heat transfer, as well as units within metallurgy that cover some fields in thermodynamics: TKK Laboratory of Metallurgy, TKK Laboratory of Materials Processing and Powder Metallurgy, and UO Laboratory of Process Metallurgy.

Most of the research in Finland concerning processes and equipment for thermal energy transformation, such as turbo machinery, continuous combustion and power plants, is not part of mechanical engineering. Research related to thermodynamics therefore seems to be very fragmented at Finnish universities. Energy-related research within mechanical engineering is primarily related to fields such as fluid power (incompressible flow), and indirectly also to power consumption/efficiency for vehicles, work machines and production equipment, and their drive trains (e.g. combustion engines or electrical drive systems).

The Applied Mechanics Department recently created at TKK, covering both solid mechanics and fluid mechanics, is considered by the panel to be a favourable reorganisation. A similar reorganisation within the field of applied thermodynamics is also recommended. Many engineering problems require combined fluid/thermodynamic modelling, so cooperation between such units should be advantageous.

3.7 Vehicle engineering

There are a few solitary units that define their research from the application area of different vehicular fields (aeronautics, automotive engineering, ship building). The size and the profile of the ship building unit are comparable to other countries, while the evaluated Finnish aeronautics and automotive engineering research teams within mechanical engineering are too small to represent the field appropriately. The ongoing reorganisation of some units will change the situation somewhat.

All of the units have research in applied mechanics, fluid dynamics etc. Some units do some fundamental research in these areas. There is, however, a lack of system-level research, for example research in vehicular design. All these areas provide great opportunities for fundamental research in design of systems engineering, complex systems, multidisciplinary optimisation, requirement management and product modelling. There was also an alarming lack of vision for future research in all of these units, which, in some cases, can be attributed to an imminent replacement of leading persons.

All units in this category have a very high dependency on projects from industry or other external institutions, for financing technical staff and facilities. Consequently, they assume the role of research establishments, which in other countries are usually organised outside universities. This means that a high proportion of the activities at the units is not research, but investigation for customers outside the university. All units also have a large proportion of personnel that are not researchers (do not have a PhD).

4 Evaluation of individual units

4.1 TKK Automation Technology Laboratory

Overview

The unit has two professors and 23 researchers. During the evaluation period, the unit's total funding has been about 1.9 million euros per year, of which the budget covered 36 per cent, Tekes 37 per cent, industry 9 per cent, the EU 7 per cent and the Academy of Finland 5 per cent. After the recent reorganisation of the university the former unit belongs to the Department of Automation Systems and Technology. It forms the Centre of Excellence in Generic Intelligent Machine research (GIM) together with the TUT Department of Intelligent Hydraulics and Automation (unit 20 in this evaluation). Through GIM, 14 PhD students, of which four are from other countries, will be funded at the Automation Technology Laboratory. Currently, there are 19 MSc students involved in the research of the GIM team in Helsinki.

Research profile

The unit does research in the field of robotics, machine automation and instrumentation, and sensor technology. The research in robotics covers a very broad area of application and many different types of robots and robotic systems such as mobile robots, underwater robots, field robotic systems for precision farming, military robotic systems, assistance robots and rescue robots. The unit also has expertise in automation of energy and power systems with focus on hybrid systems.

The current research activities within GIM cover different aspects of automation and control of intelligent mobile machines and future worksite concepts, in particular human-machine interfaces, machine control, safety, communication, fault detection and sensor technology. There is a substantial background in system theory, which is used to define challenging goals for theoretical and methodological research topics within the research projects. The theoretical and experimental research work of this unit is well balanced and can be categorised as long-term applied research.

Research quality

The unit conducts research of a very high quality. It is a well-established unit with many impressive achievements as well as international contacts. In addition, the unit has an outstanding academic leader and a very well structured and organised plan for training PhD students.

Research environment

The unit has excellent facilities for conducting research. The team has found an outstanding balance between theoretical and applied research. The environment is conducive to exceptional training of PhD students.

Research networking and interaction

The unit has several EU projects, as well as partners in Russia, Australia and Japan. The unit has recently organised FIMA, the Forum for Intelligent Machines, which also involves VTT, research units from TUT, LUT and UO, and about 40 companies interested in mobile machines and committed through FIMA to long-term applied research.

Recommendations

Increase journal publication, continue excellent work and expand collaboration with other foreign centres in the field.

4.2 TKK Laboratory of Corrosion and Materials Chemistry

Overview

The unit is placed in the Department of Materials Science and Engineering of the Faculty of Chemistry and Materials Science that started in 2008. During the period of assessment the unit had one professor, about two postdoctoral researchers, 4–6 postgraduate students and 2–4 research assistants. For the period from 2002 to 2007, the unit's funding, as a percentage of total available funds, was as follows: budget 60 per cent, industry 26 per cent, other public sources 5 per cent, Tekes 5 per cent, EU 4 per cent and Academy of Finland 0.2 per cent. Funding from industry and the EU showed a slight increasing trend. The average total funding for the period was about 0.6 million euros per year.

Research profile

The research of the unit is linked to the traditional major industries (steel, paper, marine) in Finland. About half of the research is on metallurgy. The other half involves corrosion research and some surface engineering. The main research areas of the unit are corrosion in marine technology and the process industry, technical electrolysis processes, surface engineering, and development of electrochemical measurement methods. The research starts from base metal production, extends to the manufacturing and surface treatment of a product, and ends with the examination of corrosion damage.

The unit is well known for its expertise on (i) corrosion prevention (supporting manufacturing and production) and (ii) hydrometallurgy and surface engineering. There has been some development of research methods. In recent years, new research areas have been started to answer to the needs of the Finnish electronic industry. Furthermore, research connected to industrial infrastructure is becoming a significant area of work for the unit, after ten years of silence.

The unit's staff belong to two groups, namely surface science and metallurgy, each led by a senior researcher. Current projects focus on Cu and Zn production methods (the Cu-based project involves six different copper companies from around the world), recycling of Cu/Nb/Ti scrap in superconductor production, corrosion of polymer-coated thin sheets, artificial patina on copper, chromium deposits on HS (High Strength) steels, hydrogen contamination during pickling, and corrosion of car components by de-icing chemicals.

Research quality

The corrosion-based work is the best in Finland. Internationally, the unit is known for its work linked to steels, in particular stainless steel and the cathodic coating of ice-going vessels (international player in the latter area). All research in the unit is applied, owing to funding opportunities, which have always been linked to the needs of Finnish industry. The impact of the unit's work on industry is very good. Over the years staff ambitions and aspirations for some fundamental and basic research have been frustrated by reliance on funding linked to industry, as their work is supported by companies that have strong support from Tekes.

The publication record is very poor. This is attributed to the following factors: (i) the substantial effort of the staff to secure funding, (ii) the actual size of the unit, (iii) the nature of the unit's work, substantial parts of which cannot be published, and (iv) researchers who are very good at engaging with the industrial challenges of projects but not ambitious enough to write papers for peer review or conferences.

The PhD record is poor, but not out of step with the majority of the units involved in this evaluation. A particular factor affecting PhD projects is the short-term nature of projects linked to industry, most of which do not extend beyond six months. This forces PhD candidates to continuously switch from one project to another and has a strong dispiriting effect. The unit has one international patent; the IPR is owned by the university.

Research environment

The viability of the unit is threatened by its small size, the age profile of staff, their educational and administrative loads and the range and age of the unit's facilities. Currently, the exclusive focus of the unit's work on the serving industry's projects poses a very serious threat to the academic standing of the unit.

The staff are very optimistic that new structures at TKK would have a positive effect on the size, workload and academic direction of the unit, creating opportunities for academic research, for the increase of peer-reviewed publications in the established journals of the field, and for PhD student training. The range, nature (type) and age of equipment do exert a strong effect on the future direction of the unit. Lack of specific items of equipment frustrates aspirations of staff to expand into new areas and plan long-term research for innovation. The lack of career progression opportunities at the university is also another concern for this unit.

Research networking and interaction

The unit has strong national networking and collaboration with Finnish industry and the seeds are in place for strengthening or establishing collaborations outside Finland.

Recommendations

Every effort must be made by the Department, the Faculty and TKK to assist and support the unit to slowly but steadily build up its academic research work and strengthen its academic profile. There is a very serious danger that this important unit for Finnish industry will degenerate irreversibly into a service laboratory and completely run out of ideas for future innovation. Increase collaboration with units 3, 4, 5, 6, 10 in this evaluation at TKK to build strong interdisciplinary proposals and to seek Academy of Finland funding.

4.3 TKK Laboratory of Materials Science

Overview

The unit is placed in the Department of Materials Science and Engineering of the Faculty of Chemistry and Materials Science that started in 2008 and is also a member of the TKK Center for New Materials, UMK. At the end of 2007, there were three research groups, of which one, Advanced and Functional Materials, is considered here. This group constitutes about 75 per cent of the activities of the whole unit. In the period of assessment, the number of professors in the group increased from one to three and the number of senior researchers from two to four. The former head of the laboratory also retired during the period.

Funding, as a percentage of the total funds of the unit, was as follows: budget 42 per cent, Tekes 33 per cent, Academy of Finland 14 per cent, industry 5 per cent, other public sources 3 per cent, private foundations 3 per cent, and EU and other foreign organisations 0.2 per cent. The average funding in 2000–2007 was about 1.6 million euros per year. Academy funding has been erratic and was almost the same in 2007 as in 2000. Tekes funding decreased steadily up to 2004 and increased thereafter. Industry funding has increased steadily since 2000 and in 2007 it was four times that in 2000.

Research profile

The mission of the unit is to carry out internationally acknowledged materials research that benefits society and to educate specialists in the field. The strategy of the unit is to develop key competencies for materials characterisation and to utilise them in selected areas in cooperation with national and international partners, while selecting focus areas on the basis of scientific challenges, application potential and relevance to Finnish industry. Research priorities are on functional materials (micro- and nanocomposites), magnetic and active materials, new steels and metal-matrix composites, as well as on silicon and microsystems (new silicon wafers and microsystem structures).

The researches carried out in the unit are almost completely experimental and staff collaborate with other groups for theoretical work. There has been research on technique development, related to characterisation of twinning stress in MSM (Magnetic Shape Memory) materials, with some work in this area being quite unique and receiving international recognition. Funding opportunities have forced the unit (i) to diversify its activities, but in doing so momentum gained from pioneering work on MSM was lost, and (ii) to steer clear of risky and blue-skies research even though foundations for such work are in place.

Research quality

Compared to most of the other units in the evaluation, this unit has an impressive publication record, which is comparable to overseas materials groups, with journal publications outnumbering those at conferences. Staff of the unit have national and international patents. However, it is noticeable that peer-reviewed papers have less and less been published in journals that would best correspond to the core activities, probably reflecting that funding opportunities have started to affect even this area of academic activity. Nevertheless, there are publications of quality and original work.

PhD student numbers are disappointingly low, in line with other units in this evaluation but out of step with overseas materials groups. More than 40 per cent of the PhD students are working outside the university to earn money to survive; this has an adverse effect on the duration of PhD work and submission rates and statistics.

The unit, through its work on MSMs, is known internationally but now faces significant competition from other research groups that have started research on these materials. Industrial impact of the research has been significant with industry starting spin-off companies on the basis of earlier R&D done in the unit. However, the only monetary benefits for the unit from the IPR that it has generated have been short-term research contracts from industry, very much focused on the needs of the latter. It is highly likely that the achievements of current research work will allow the unit to have a spin-off company in the next two to three years.

Research environment

The size of the unit, the age profile of its staff and the lack of career progression opportunities in the university are of some concern. Departure of younger members of staff could have a strong adverse effect on the viability of the unit. The unit relies on high-cost equipment for its experimental research. Some of the equipment is relatively new and state-of-the-art, but the great majority of the experimental facilities are old. If equipment were not to be replaced in the near future, the damage inflicted on the research would be irreversible. The age of the equipment is also of concern when PhD projects are considered.

There is good team spirit and collegiality in the unit and strong willingness to put mechanisms in place to plan for the future. To date, attempts for long-term planning have been frustrated by funding opportunities and policies. There are good ideas and strong aspirations on which high-quality research could be built in future, but also frustration that efforts must focus not on scientifically challenging issues where long-term innovation is possible, but on what is likely to be fundable in the short term in Finland. Foundations are in place for future research on functional coatings and on materials related to energy production. The unit is also well placed to play a key role in MeKo-SHOK (Section 1.2) as concerns breakthrough materials, particularly if they were to collaborate with other university groups inside and outside TKK .

Research networking and interaction

There is outstanding international networking and collaboration; national collaboration and networking with academia and industry are also very good. Within Finland, industrial impact is good.

Recommendations

Utilise international links to branch out in new research areas, use own IPR to fund long-term innovation and collaborate with other academics in Finland to boost basic research in new areas of research. Increase collaboration with units 2, 4, 5, 6, 10 in this evaluation at TKK to build strong interdisciplinary proposals to seek Academy of Finland funding.

4.4 TKK Laboratory of Metallurgy

Overview

The unit was formed in the 1940s and is currently placed in the Department of Materials Science and Engineering of the Faculty of Chemistry and Materials Science that started in 2008. In 2007, the unit had two professors, of whom one is emeritus, three senior researchers, three postdoctoral researchers and twelve postgraduate students. The age profile of the staff is mixed.

The unit's funding, as a percentage of total funds, was as follows: budget 38 per cent, Tekes 29 per cent, industry 19 per cent, EU 11 per cent and Academy of Finland 3 per cent. The average funding in 2000–2007 was about 1.5 million euros per year. The modest funding from the Academy has been compensated by funding from the EU and Tekes, which show an increasing but not very strong trend. External funding is vital for the survival of the unit, which uses such funds to fund staff (about 8 posts) and pay rents that are not covered by university core funding. A very significant senior staff effort goes towards securing external funding, and this adversely affects research, training and educational activities.

The unit cooperates closely with all Finnish and several European and overseas steel companies. The unit is in charge of the Graduate School on New Materials and Processes and every two years organises the Nordic Symposium for Young Scientists in Metallurgy.

Research profile

The unit has core competencies in thermodynamics and kinetics of high-temperature processes, mass and heat transfer, fluid flow and surface phenomena. Research activities concern both experimental work (e.g. measuring component activities in metal alloys and slag, diffusivities in liquid and solid phases, reaction kinetics, and surface tension) and mathematical modelling by applying commercial or in-house-developed software (thermodynamic and kinetic models, computational fluid dynamics software and coupled model packages). About 60 per cent of the research is of a basic nature.

The industrial relevance of the research is in iron- and steel-making processes and casting, copper and nickel processes and other high-temperature processes for materials production. The research aims to minimise energy consumption and harmful wastes or emissions such as CO_2 as well as to develop new metal alloys and composites with improved properties. Typical examples are production methods for "clean steels", steels with superior machinability, novel grain refinement technology, innovative copper alloys based on assessments of phase diagrams for multi-component alloys, and applications of boron in steels. Intensive work on surface phenomena, especially measurements of surface tension of liquid and solid materials, has led to applications to develop metal-ceramic special materials.

Research quality

The unit is well-known internationally. It is one of the few surviving chemical metallurgy groups and has great potential to significantly improve its international visibility. The unit's research has quality and a significant part of it is original. The impact of the research in Finland is significant. For example, models developed in the unit are used in industry and they have helped solve quality problems (defects, process optimisation, fluid flow etc.). The publication record is strong with a tradition of publishing peer-reviewed papers in established journals of the field. It is anticipated that the number of peer-reviewed publications will increase in future.

The low number of PhD students, compared to overseas materials research groups, is of concern, and every possible avenue should be followed to improve the PhD training record.

The excessive focus on ferrous metallurgy is a great strength as well as a weakness of the unit. Currently, the research is very much based on steel industry support. The staff recognise that they will have to integrate more closely with material science without losing their distinct identity, and start to address long-term issues that are not exclusive to ferrous metallurgy.

Research environment

The unit benefits from a wide range of experimental and modelling expertise and facilities including a very wide range of modern software. The age of the equipment is of concern as some pieces of equipment are in urgent need of replacement. The unit would like to have opportunities to do more basic research; staff were very concerned that the current 60–40 split between basic and applied research would be very hard to maintain in future.

There are meetings to plan for the future, for long-term innovation and for new research avenues. These are, however, difficult to realise as the unit, like every other metallurgy group in the country, is strongly steered by different financing instruments. Funding agencies very much define how the research is run. The top-down approach to metallurgical research leaves very little space for bottom-up initiatives and planning for long-term innovation.

Research networking and interaction

Outstanding international networking and collaboration across all continents is present. National collaboration and networking with academia and industry is impressive. Within Finland, industrial impact is very good.

Recommendations

The unit is very well placed to explore opportunities for interdisciplinary and multidisciplinary research. It features a pool of high-quality expertise that Finland needs and that would allow the unit (a) to increase its portfolio of fundamental research and (b) to gradually diversify its research in new areas such as coatings, modelling and energy materials. There is a danger that if staff were not to be replaced in time the unit would struggle to maintain its international visibility. The unit should explore ways to increase funding by exploiting its IPR.

4.5 TKK Laboratory of Processing and Heat Treatment of Materials

Overview

The Laboratory of Processing and Heat Treatment of Materials is part of the Department of Materials Science and Engineering at TKK . The research team consists of one professor (two professors before 2002), two senior researchers and a number of PhD students. The average research funding in 2000–2007 was about 0.7

million euros per year with 62 per cent coming from the core funding by the university. Due to the small number of researchers the unit's main activity is teaching. However, there is an increasing emphasis on research. Laboratory renovation during 2002–2004 has hampered research activities.

Research profile

The unit is teaching-focused, with increasing research activities over the last few years. The research areas cover forming, rolling, hot extrusion, forging and heat treatment of metallic materials, simulation and modelling of deformation processes, tribology and material design. The unit has done pioneering work in incremental forming and developed combined heat treatment and forming process. The research emphasis is on the understanding of plastic material flow and manufacturing production methods, properties of materials, material selection and surface engineering. Most research projects are industry-relevant and driven by industrial needs.

Research quality

The unit has had six journal publications, 17 conference papers and one PhD graduation during the period 2000–2007. The unit has recently improved the number of PhD students, with three of them funded by the graduate schools (Graduate School of Metallurgy, Graduate School on Metallurgy and Metals Technology).

Research environment

The unit has experimental facilities for tensile testing (both static and dynamic at normal and high temperatures), stress and strain testing, corrosion testing, induction heating, plasma cutting and robotic incremental forming. They will have robotic system and tensile testing facilities within five years.

During the period 2002–2004, the laboratory was restructured, which has caused serious interruptions to the research. The unit has lost many large projects and industrial partners. The unit has not had a technician dedicated to the laboratory since 2004. The departmental laboratory supervisor provides partial support to the laboratory work within the unit. More than 70 per cent of the unit's professor's time is spent on teaching.

Research networking and interaction

The unit collaborates with a number of companies (mainly metal industry such as Outokumpu, Rautaruukki, Imatra Steel and Fundia Wire) and academic institutions both in Finland and in other European countries. The unit has participated in research training and mobility projects (solar energy) with Spain and Hungary, and has hosted two visiting professors. There is little collaboration with other research groups within the university.

Recommendations

The panel encourages the unit to put emphasis on PhD training and completion. The unit should develop a research strategy to reduce equipment dependence and to explore the potential for more fundamental research in modelling and simulation and put more effort on developing the incremental forming process. The unit also needs to give more priority to high-quality research output in the form of journal publications. The unit is encouraged to explore the opportunities of the new structure in the department to provide technician support. Finally, the unit needs to develop a strategy for equipment upgrading and for infrastructure investment with a possibility to provide central facilities for wider access and use.

4.6 TKK Laboratory of Materials Processing and Powder Metallurgy

Overview

Over the assessment period (2000–2007), the Laboratory of Materials Processing and Powder Metallurgy had one professor and on average a total of approximately 18 FTEs of research staff.

The unit has attracted 74 per cent external funding from the total average funding of about 1.1 million euros per year over the assessment period. Tekes, industry and the EU are the main sources of external funding. Although only a small proportion of funds (€10,000 per year) comes from the Academy of Finland, this funding has been very important in supporting preparations for launching EU research proposals.

Research profile

The unit conducts research in thermodynamics of materials, advanced materials solutions, fuel cells and hydrogen, powder metallurgy, material processing and modelling industrial processes. The research quality is high by international standards. The Powder Metallurgy Laboratory is unique in Finland and has no competitors in the field.

Due to the high level of industrial funding, the unit's research is mainly of an applied rather than a fundamental nature. However, there is growing research activity in modelling materials processing. The unit conducts a periodic review of its research policy every 2–3 years by launching internal seminars and evaluations.

Research quality

The unit produces a large number of international journal publications with a total of 53 refereed journal papers, that is, an average of 6.6 journal papers per year in the assessment period (2000–2007). One international patent has been registered. Also, 69 papers were published in conference proceedings over the assessment period. The balance between journal and other publications is very good. There is evidence of fundamental research from the publications.

The laboratory receives good industrial support for its research activities and participates in many research projects within the university and in Europe.

There were only five PhD completions in the assessment period, which is low for a leading research unit. Many PhD candidates leave for better paid careers in industry before completing their PhD theses. All PhD graduates in the assessment period work within industry, which highlights the industrial relevance of the PhD research. However, the expertise developed in the PhD projects needs to be continued within the unit. More funding is required from the Academy of Finland to provide full funding and financial stability for PhD candidates.

Research environment

The laboratory has extensive experimental facilities including laser particle analyser, thermogravimetry, gas and microwave furnaces and powder metallurgy equipment. The laboratory facilities appear to be well funded with sufficient funds for maintaining and improving the equipment.

Research networking and interaction

There is a high level of national collaboration with other universities and industrial companies. Members of the group are also active in visits abroad, and in attracting visitors from Japan, the UK and Australia. The unit is very active in EU consortia, which reflects its high standing in Europe. Staff are well represented in European networks, and maintain a high level of participation in editorial boards and professional committees.

Recommendations

Although the group has been very successful in attracting external funds from industry, the panel feels that the research is dominated and driven by industrial needs, at the expense of more fundamental scientific research. The unit should develop a strategy for long-term basic research. The panel feels that this unit has a good potential for pursuing more innovative research topics and subsequent dissemination in international journals.

The group has excellent collaboration with other units at the university and responds well to industrial needs. However, there is a need to develop a strategy for taking the lead in research innovation and creating new research directions. The panel recommends that expertise developed by the PhD researchers who leave the unit be captured and retained within the unit.

4.7 TKK Internal Combustion Engine Laboratory

Overview

The unit has currently one professor, one senior assistant, one laboratory manager, technical staff, one secretary, eight researchers and five research assistants (graduate students). The unit has a good balance between core funding and external funding, including Academy of Finland funding. The average total funding in 2000–2007 has been about 1.3 million euros per year, of which the budget covered 30 per cent, Tekes 33 per cent, industry 15 per cent and the EU 12 per cent.

The research group is part of the TKK Department of Energy Engineering as from 1 January 2008.

Research profile

Internal combustion engine technology is a highly multidisciplinary field of technology. The field of research in internal combustion engine technology at TKK was re-defined in 2007 by the Scientific Council of the Department of Mechanical Engineering as "Internal combustion engines, theoretical and experimental methods of engine research, design and development, combustion and emission". It is the only unit in Finland within this research area. It is centred on diesel engines and their certain phenomena, in support of the strong Finnish diesel engine industry. The mission is to concentrate on the most demanding topics, such as cylinder physical phenomena, combustion, flow field and emission reduction. This means that the unit works with advanced methods for simulation and experimental research.

Research quality

The unit is very strong in the area of large diesel engines. In this area, it has a strong position and an ambition to be the leading unit worldwide. Most of the research is applied. However, basic research would be more desirable, but suffers from lack of funding. It would be needed especially in the field of fluid mechanics and optical measurements.

The scientific output in terms of PhD and journal publication has been rather low, but the area has been in a start-up phase, with a new professor appointed a few years ago. Furthermore, the publication tradition within the whole automotive area is much centred on conferences. The trend, however, is very positive. The plan is to have two PhDs within the next two years.

The number of referee publications of the laboratory will be further increased, especially on experimental scientific research. It should be noted that the unit has only a few restrictions on publishing results that have come from industrial projects, which contradicts what some other units experience. It is also worth noting that the unit has obtained two positions in the graduate school coordinated by the Academy of Finland.

Research environment

The research environment seems very good, with a very positive leadership. They do have a high teaching load, which has a negative effect on the research. The two graduate school positions that the unit have has had a very positive effect on the PhD studies for those involved.

Research networking and interaction

On the national level, the unit collaborates in one project with the TUT Department of Intelligent Hydraulics and Automation, within TKK , with Åbo Akademi University and with VTT. The unit has also an active international network with leading institutions in the area. The unit is active in the International Energy Agency IEA and the head of the unit is the Finnish representative in the executive committee of the IEA Combustion Agreement.

The unit's societal impact comes today from the extensive cooperation with industry. However, in future, the impact on emission reduction will be the most important issue.

Recommendations

The unit has a positive development. There is already an emphasis towards scientific results, that is, PhDs and journal articles. From a scientific point of view, they are well positioned with both theoretical tools and experimental facilities to take on a range of research tasks. Therefore, the unit should have opportunities to apply for Academy of Finland funding also in future. The education workload is very high and it is recommended that this be addressed, for this unit to continue to have a positive development.

4.8 TKK Laboratory of Aerodynamics

Overview

The HUT Laboratory of Aerodynamics is the only research site in Finland specialised in aerodynamics and flight mechanics. The group has at present one professor, who is leaving the unit. There are three other persons with a PhD in the group, which provides a solid basis for research. There is, however, only one PhD student and the production of PhD students has been low. In addition, there are three technical personnel.

The total funding during 2000–2007 has been about one million euros per year, of which 41 per cent has been covered from the budget. There is external funding coming from the Academy of Finland (2%), Tekes (9%) and the EU (8%). The funding from external customers (40%) is, however, larger than all of these put together.

Research profile

The research at the unit is in primarily three fields. The first is computational fluid dynamics (CFD). This has involved development and application of a Reynolds-Averaged Navier-Stokes (RANS) flow solver, called FINFLOW. The second branch can be described as flight mechanics. This entails mainly modelling and simulation of flight vehicles. The third and most visible and traditional activity is experimental study using nationally unique wind tunnels.

At present, there is no real strategy for the future due to the turmoil with reorganisation and because the professor is leaving the unit.

Research quality

The unit led the development of the Finnish CFD code FINFLOW that is today used and further developed by several other units, that is, ship building, fluid dynamics and thermodynamics. They do publish in journals although not to the extent expected from a basic research area like this. The limited work they do publish is, however, of a good quality. It seems that the bulk of the research at present is in the area of CFD.

There is a very large portion of projects for external customers. A considerable number of these are made in the wind tunnels. In this respect the unit has the role of a research establishment for aerodynamics. This means that the bulk of the activities in the wind tunnels is investigation for external customers.

Research environment

The unit is in trouble and will shortly face a change in its leadership. This means there will be a lack of guidance during a period when it is really needed. Furthermore, there is an imminent reorganisation where the unit will become a part of the new unit Applied Mechanics. The unit has three wind tunnels that have become too costly to maintain with a new cost model for facilities. This is a serious concern within the group. There is also a high workload in teaching. The doctoral training has taken a very long time for the degrees awarded. There have been only four PhD completions during the period of evaluation.

Research networking and interaction

This is the only aerodynamics unit in Finland; there are, however, other units at TKK that also deal with computational fluid dynamics. In the past, collaboration seems to have been sporadic among them. However, in the new unit organisation, the unit will be merged into the applied mechanics group including also aspects of fluid dynamics and thermodynamics.

Recommendations

The situation is changing rapidly with the merger with the new Applied Mechanics unit. This is probably a move in the right direction, since the group is clearly sub-critical on the academic side. In this new setting, there is hope that some of the research will develop in a positive way.

One concern is the wind tunnels. The trend abroad is, however, to find other establishments that can take them over, and use them commercially. The wind tunnels are used primarily for external customers. And in such a situation it might be natural to separate the activities. Some agreement has to be made considering the use of the facilities for research. As the volume of Finnish aerospace industry is small, the unit has no strategic role in the Finnish innovation system. With increasing globalisation, however, the unit can and must turn more to the international scene if they are going to have significance in future.

4.9 TKK Laboratory of Automotive Engineering

Overview

The unit has the only automotive engineering chair in Finland. The laboratory has one professor and on average a total of five FTEs of research staff. Total average funding is 0.8 million euros per year. Core budget funding is the main source of funding with an average of 45 per cent. Funding from the Academy of Finland amounts to 3 per cent, Tekes to 8 per cent, other public funding to 3 per cent, industry to 22 per cent and the EU to 18 per cent. Each year, 20–25 new students take the basic courses as major or minor subject and about seven students complete an MSc degree. No PhD student has graduated during the evaluation period.

Research profile

The main focus of research activities is on automotive technology, mobile working machines and railway vehicles. More weight is placed on the first two areas. The subfields tire-road interaction, simulation of driving dynamics and hybrid heavy vehicles are pursued vigorously. Faculty and staff have a high level of scientific and practical experience. Many projects on working machinery in forest industry, mining and load handling have been successfully completed and they have resulted in innovative developments in practical applications. The unit is well known in Finland and also elsewhere in the EU in the field of vehicle engineering.

Research quality

A very good group with complementing talents and skills has been established. The group has identified the industrial relevance of research works such as tire-road contact phenomena, multibody systems simulation based on this and vehicle electronics, and placed emphasis on these areas.

The unit produces an annual average of 0.5 articles in refereed journals, 4.5 articles in refereed proceedings or other volumes, 0.5 monographs excluding theses and 9.1 other scientific publications. Many of the other publications are technical reports and articles in non-scientific magazines. Not all of them are refereed. The journal paper output is very low. The nature of the work is about 80 per cent experimental and 20 per cent simulation. The emphasis has been on applied and industrially oriented research.

Successful EU-funded projects have been conducted, such as VERT, VERTEC, TROWS, APOLLO, FRICTION and KOVERA. Areas that are very interesting to students with more practical interests and talents are covered in the research activities. The group has achieved solid international reputation in the field of tire-road contact, is contributing to the mining, harbour and forest industries in Finland, and has been training and supplying well-trained engineers and researchers to Finnish vehicle and transportation industries in the chosen specialty area.

The challenges in becoming a unit with international recognition include productivity-based leadership, a tradition of very low journal publication activity, limitations imposed by industry on publication of research results, high equipment costs (capital as well as maintenance), a small team size, and a kind of "singular" position in Finland.

Research environment

The unit has excellent, state-of-the-art test facilities that are critical in order to conduct high-quality research. Continuous upgrading and maintenance has been carried out over the years. The rental costs for facilities are high.

Research networking and interaction

The group has recognised the benefits that can be obtained from interdisciplinary collaboration with units of automation, machine design, power electronics, physics and hydraulics, especially as regards hybrid vehicle technologies. In this regard, excellent internal interdisciplinary collaboration within TKK is present. A high level of national, EU and international networking and collaboration has been established. Transport industries in Finland and other EU countries have to a large extent been involved on a continuous basis in the unit's activities.

Recommendations

The publication record, in particular the journal publication record, needs significant improvement. The unit should achieve more visibility and international recognition through active journal publication. Also, the PhD degree output needs to be significantly increased. The panel observes that the current situation has potential to cause a lack of focus on PhD training. This should be avoided by carefully examining the strengths of the group to identify a niche in a specific field. They should focus all research activities on that field. It is strongly recommended that more emphasis be placed on theoretical and modelling aspects of research work. In this regard, strong collaboration with researchers from theoretical departments or units within and outside TKK is needed.

A good balance of experimental and theoretical research should be achieved and more emphasis placed on fundamental research. There is wide scope and potential for such fundamental research in problems addressed in current projects. They have to be utilised.

The group leader nowadays spends more time on administration. This will negatively impact on the research. Also, a new professor must be hired.

4.10 TKK Laboratory of Engineering Materials

Overview

Over the assessment period (2000–2007), the TKK Laboratory of Engineering Materials had an average FTE of one professor and a total research staff of approximately 21. The unit is responsible for teaching physical metallurgy, material selection, fracture mechanics, non-destructive testing and welding.

The average total funding over the assessment period was 1.9 million euros per year, of which 1.1 million euros was external funding. External funding for research mainly comes from Tekes, industry and the EU, with a small proportion of funds (2%) from the Academy of Finland. The self-assessment report is very well written and positively addresses the strengths and weaknesses of the unit.

Research profile

The main research activities are in the field of material science with applications in the energy sector (nuclear and conventional power plants), transport and process industries. The research is mainly applied and experimental in nature. However, there are very good modelling and simulation activities, including welding and thermal fatigue cracks. The research in thermal fatigue, control of cracking and friction stir welding is of a high quality by international standards. The unit is unique in Finland in conducting high-quality research in friction stir welding and thermal fatigue.

Research quality

The unit has a high output of international journal publications with a total of 51 refereed journal papers, that is, an average of 5.4 journal papers per year in the assessment period. This reflects the high quality of the research in the unit. Also, 119 papers were published in conference proceedings over the assessment period. The balance between journal and other publications is very good. One international patent has been produced by the unit.

There were eight PhD completions in the assessment period (2000–2007). A good proportion of PhD graduates are employed in industry. A lack of full funding for PhD students has resulted in most PhD completions taking longer than four years. Many PhD students are attracted by better career progression and better salaries offered in industry, which often results in them leaving before completing the PhD.

Research environment

The laboratory has extensive experimental facilities that include advanced welding techniques, residual stress measurement, thermo-mechanical testing and metallography. The laboratory also has a license to operate friction stir welding/ processing equipment (FSW/FSP) and several advanced facilities especially designed for narrow-gap welding (NG-TIG/SAW/MAG). There is also a FEGSEM (Field Emission Gun Scanning Electron Microscope) with advanced spectrometry and diffraction accessories (EBSD/EDS), thermal fatigue test systems, X-ray diffraction equipment, and equipment for optical strain measurements. The facilities are impressive, combining simulation, modelling, testing and other experimental work.

Research networking and interaction

The unit is very active in national collaboration with other units at TKK and other universities and institutes in Finland (VTT, TUT, LUT and UO). International networking activities have taken place with many countries and regions, including the US, Europe and Japan. Members of the unit have a good external profile in membership of professional committees, particularly in the nuclear energy sector. The level of invited lectures and participation in editorial boards and conference committees is good.

Recommendations

The panel is generally impressed with the high quality of the research in this unit. The unit has the potential to become a leading centre of excellence in functional coatings in Finland. The unit would greatly benefit from large investment in infrastructure for friction stir welding processing and functional coatings.

As there is only one professor in the unit, the panel recommends that the unit recruit another professor with expertise in welding and non-destructive testing to reach critical mass. This would enable the unit to actively collaborate with, and if feasible, merge with other groups at TKK involved in materials science research. This would create new momentum for generating more interdisciplinary innovative research work. The new departmental structure at TKK should provide an ideal environment for building on the strength of existing research areas.

The panel recognises the excellent industrially-funded research in welding and coating, but feels that the research is dominated by industrial needs. The panel therefore recommends that the unit extend its research to cover more fundamental innovative developments and more theoretical and computational modelling activities. This would place the unit in a stronger position on an international scale.

4.11 TKK Laboratory of Foundry Engineering

Overview

The TKK Laboratory of Foundry Engineering is now a research unit – Cast Product Technology – within the new TKK Department of Engineering Design and Production (within the Faculty of Engineering and Architecture). The unit has one professor, six active research staff, three PhD students, one laboratory manager and one technician. This is the only national chair in foundry engineering, which also includes the task of coordinating the TUT Foundry Institute.

The unit's total funding amounts to about one million euros per year, distributed as follows (2007): university budget 42 per cent, Academy of Finland 15 per cent, Tekes 1 per cent, other public sources 19 per cent and industry 23 per cent. There was also a smaller amount (about €55,000 per year) of EU funding during the period 2002–2004. Since 2003, when the new professor took up the position, there has been a positive development in terms of staff, funding and scientific publication. The unit's total funding has been stable over the evaluation period, while the number of staff has increased.

Research profile

The unit's research profile is foundry processes (e.g. investment casting for near net-shape), cast materials (cast iron and light metal casting; Al, Mg, Al foams, specialty materials) and component casting, including aspects of design of cast components. The unit's research has historically been mostly experimental and applied, in industry cooperation.

Other new research areas are ICT in the foundry industry, the "foundry service concept", that is, comprising also related processes such as cleansing, machining and design of cast components, as well as prototype casting, SME foundries and foundry-related environmental issues – LCA/LCC (Life Cycle Assessment/Cost).

A number of future research topics have been listed in the unit's strategic planning: (i) Future of SME foundries (EU Forestall project proposal); (ii) Industry implementation of enhanced ramp-up and prototype production in Finland, to be combined with outsourcing of full-scale production; (iii) Ultra flexible iron foundry process and flexible moulding methods, patternless moulding; (iv) Particle reinforced ferrous metals, and ultra high-strength high-Si steel castings; and (v) Efficient testing methods in iron foundries to estimate the mechanical and physical properties of castings.

Research quality

So far, there has been a moderate number of scientific publications (approx. nine per year of which two journal publications). There has been only one PhD, in 2006, but two PhDs and two Licentiates are planned during 2008. The unit faces a number of challenges: a short history as an academic subject; a limited budget; weak funding for infrastructure; no funding for independent own research; funding organisations lack interest; non-continuity in projects and funding; a small size; as well as a lack of long-term commitment from industry. Furthermore, the research leaders do not have PhD degrees. However, after the change of professor (in 2003) the situation has improved significantly. It is now a unit with good potential. The number of students has increased considerably. Previously, there were only short-term Tekes-industry projects, but in 2005 the Academy of Finland funded (with a total sum of €0.95m) a four-year FC-ICT project on ICT support and the foundry service concept (casting, finishing-machining and casting design) was initiated, in cooperation with TKK Machine Design and HUT SoberIT (Software Business and Engineering institute). In this more long-term project, there are two PhD students, and two PhD graduations planned for 2008.

Research environment

The staff are multidisciplinary and multiskilled, with a strong background in materials science. The laboratory premises are small and a bit out-of-date. There are, however, relatively modern furnaces at the unit, and two big furnaces at the TUT Foundry Institute can be used within their close cooperation. The TKK unit is primarily focused on non-ferrous castings, while TUT focuses on steel. The TKK unit also has a prototype printer for wax models in investment casting.

The teaching load is high: the unit gives seven courses at basic, graduate and postgraduate levels, as well as does teaching at other schools. Each year, 4–5 MSc students take foundry as main subject, and about 50 students per year take it as minor subject.

Research networking and interaction

As cast components play an important and also increasing role in the Finnish manufacturing industry, the unit has established strong relations to industry. On the academic side, the unit cooperates closely with the TUT Foundry Institute. Many pieces of expensive infrastructure and equipment (furnaces etc.) are available at the institute. Other national university partners include TKK Machine Design and TKK SoberIT in the FC-ICT project with four-year funding from the Academy of Finland, within the research programme KITARA (Application of Information Technology in Mechanical, Civil and Automation Engineering). The unit also cooperates with TKK Production Engineering and VTT.

International contacts are primarily within the Nordic countries: DTU in Denmark and SweCast in Sweden. There has been a visiting researcher contact (6 months) from the University of Bari in Italy, and the professor has been an invited speaker at conferences in China, the Czech Republic, Spain and Norway.

Recommendations

Increased scientific publishing, PhD training and international research cooperation is strongly recommended.

The Academy of Finland is strongly recommended to continue the FC-ICT project, with further development in a next phase. The panel sees many opportunities for the unit in multidisciplinary research, for example in cooperation with what corresponds to the previous TKK Laboratory of Metallurgy (unit 4 in this evaluation). Research in integrated and ICT-supported production systems as well as new technologies for flexible and high precision castings should have a good potential.

A problem for laboratory-intensive research is how to afford reinvestment and maintenance as well as operation of expensive equipment. Other channels for funding of expensive equipment should be preferable, as it is usually not possible to cover the cost on research project budgets.

4.12 TKK Laboratory of Lightweight Structures

Overview

The group is currently led by one professor. Up until the end of 2007 one professorship in aeronautical engineering was allocated to the laboratory. As from the beginning of 2008, the laboratory belongs to the Department of Applied Mechanics of the Faculty of Engineering and Architecture. The laboratory has a total research staff average FTE per year of approximately 12.

The budget funding covers about 50 per cent of total funding, which was on average about one million euros per year during 2000–2007. No funding has been obtained from the Academy of Finland during the period. Funding comes also from Tekes (6%), other public sources (17%), industry (20%) and the EU (3%). The teaching load is distributed among the entire staff. However, the professor still has to teach five courses and spends 30 per cent of his time on teaching. In addition, as head of the department he has a considerable administrative load.

Research profile

The main areas of research are composite structures, mechanics of thin-walled structures, fatigue of composites and repair of metallic and composite structures. The emphasis has been placed on aspects of the mechanics, design and manufacture of lightweight structures. The main focus of research has been on aerospace structures. However, some work on automotive structures has also been conducted. Faculty and staff have a high level of scientific and engineering experience.

Until the end of 2007, research activities have concentrated on the simulation of first-ply and progressive failure of composite laminates based on finite element stress analysis, characterisation of stress-strain relations, material degradation models, damage tolerance of composite structures, and repair of lightweight structures. The research work conducted is experimental and applied by nature and it has very good industrial relevance.

Current projects focus on advanced low-cost aircraft structures, analysis and testing of composite wing ribs, beam structures, single-flap driving system, composite impeller and lightweight wear-resistant hybrid materials. The latter project is conducted in collaboration with TUT and relevant industries. Successfully completed earlier projects have resulted in ESA (European Space Agency) software and one spin-off company, fatigue life prediction, and the development of spoiler, wing ribs and satellite components. New injection techniques have also been developed.

Research quality

The unit produces an annual average of 0.1 articles in refereed journals, 2.0 articles in refereed proceedings or other volumes, 0.1 textbooks and other research-related publications, and 0.4 other scientific publications. The journal publication record is too low. Only one PhD student graduated from the unit during the evaluation period.

Research environment

Equipments and test facilities related to manufacturing, mechanical testing and the repairing of polymer-matrix fibre-reinforced composite structures are available. However, the facilities are about 20–30 years old and need upgrading. The group has mentioned that it has been too busy with industry projects and contract works, and also that it has been hard to recruit qualified researchers with good talent and skills.

Research networking and interaction

The unit has identified and established collaboration internally with other TKK units, as well as with TUT, VTT and relevant industries. Foreign collaboration activities have been achieved with German and other EU universities. Contractual work for ESA/ESTEC, DLR Braunschweig, Airbus, Patria, the Finnish Air Force and the Finnish composite industry has been undertaken and successfully completed.

Recommendations

The unit does not seem have any trend and lacks motivation. It also lacks critical mass and is missing out on abundant research opportunities, especially in the field of composites. The research areas, especially composite materials and structures, have significant potential to identify and carry out basic and fundamental research. The unit should take advantage of this opportunity to formulate fundamental-level research projects and obtain funding from the Academy of Finland.

The PhD output and publication record is very low. This problem should be corrected by recruiting more PhD students and concentrating more on fundamental research. The unit has one graduate school position. The unit should fill this position and get one more. There are no senior researchers in the unit at present. This deficiency should be removed.

The unit should develop strong collaboration with other units, such as the engineering mechanics unit and the engineering materials unit, and take on joint projects. The work on composite mechanics and fatigue of composites can benefit significantly from such collaboration and joint research.

Collaboration with most other Finnish universities and EU universities is lacking. This deficiency should be addressed. There are excellent research opportunities with EU countries such as France, Belgium, the UK and Germany, where significant composites research has long been conducted. The unit should develop strong collaboration with research groups and industries in these countries.

The unit should convince industry to carry out also basic research and to publish research results. The laboratory facilities need upgrading and further development to support state-of-the-art research on composites.

The teaching load and administrative load is too high, which affects adversely the research output and quality.

4.13 TKK Laboratory of Machine Design

Overview

The main research focuses of the Laboratory of Machine Design are product development and mechatronics. The research areas are integrated product development, product development methodologies and CAD/CAM/CAE (computer aided design/manufacturing/engineering), tribology, fluid power and paper machine technology. At the end of 2007 the unit had four professors, six researchers with PhD and about fifteen PhD students. There is also a number of other academic and technical staff. The funding is about 3.3 million euros per year and fairly balanced between core funding (41%), the Academy of Finland (5%), Tekes (22%), the EU (1%) and industrial contracts (24%).

Research profile

The main focuses in research are product development and mechatronics. The unit is a mixture of several more or less connected disciplines. At this time, the strategies of the different subfields are more expressed than at the unit level, and it will take some time before a common research strategy can be formed.

Research quality

The separate subfields are at this time rather different. Some of the areas, such as biotribology, have a high international level, while others are more on what is the average level in Finland. Being an applied research unit, the publication record is reasonable, especially compared to other mechanical engineering units in Finland.

There is some concern, however, that this might not be so evenly distributed among the members of the unit. The quality of the research in several areas is very good, and there is potential to publish more.

Research environment

The unit has recently been reorganised through a merger of several smaller units. This appears to have been a successful move, as indicated by the members of the unit, who appreciate that they can share expertise and research cultures. The unit has a sufficient number of people at the PhD level to provide a sound academic environment. The unit claims, as many other units, to have a very high teaching load.

The unit has extensive experimental facilities that are well equipped.

Research networking and interaction

The unit has extensive international collaboration and networking and participates in EU projects. An applicant from France was appointed to the new (fifth) professorship. There is also collaboration with units at other universities in Finland. The unit also has a very large industrial network and an important role in the Finnish innovation system. There is a trend towards more long-term relationships with industrial partners, which leads to more long-term projects more suitable as research projects for PhD students.

Recommendations

The unit has a positive development and has potential to reach a respectable international level. The group should emphasise making PhD training more efficient and increasing the number of journal publications. Furthermore, the unit needs to integrate their individual visions to a common strategy. They should continue keeping an appropriate balance between basic and applied research, and continue to build long-term relationships with industry, for more long-term and proper research projects. The theoretical side can be strengthened through collaboration with the new applied mechanics group.

4.14 TKK Laboratory for Mechanics of Materials

Overview

The unit consists of two professors working within the solid mechanics area. The laboratory employs one full professor, one pro term professor, one senior lecturer, one laboratory manager, two teaching assistants, four doctoral students, three laboratory technicians, one secretary and several research assistants and classroom assistants. The position of the pro term professor will be filled as a full professor during 2008. One professor retired two years ago and that has affected the unit. Since 2008, the unit belongs to the Department of Applied Mechanics, which consists in addition of one professor in fluid mechanics, two professors in aeronautical engineering and four professors in marine technology.

Budget funding is the main source of funding with an average of 73 per cent. Funding comes also from the Academy of Finland (5%), Tekes (1%), other public sources (3%), industry (13%) and the EU (5%). The average total funding in 2000–2007 was about one million euros per year.

The unit has an exceptionally heavy teaching load. There are more than 300 students participating in an introductory mechanics of materials course and up to 750 students in an introductory dynamics course. The laboratory is responsible for advanced courses at the MSc level; there are more than 50 students in a typical advanced course. The unit is coordinating a graduate school on technical mechanics, through which one or two courses on various topics of solid mechanics are organised annually. The teaching load has adversely affected the research activities of the unit.

Research profile

The unit has been conducting theoretical, numerical and experimental research within the fields of mechanics of materials and engineering dynamics. The most important current research areas are (i) discontinuum mechanics and the discrete element method, (ii) ice mechanics and ice loads on marine structures, (iii) material modelling, (iv) finite element method, (v) experimental mechanics, and (vi) structural health monitoring. The common theme joining these research areas together has been modelling, and especially material modelling. Experimental research on static, fatigue and vibration response of materials and structures is also conducted.

The Laboratory for Mechanics of Materials offers advanced testing and analysis. Modal analysis of complicated structures, balancing of rotors of turbojet engines and development of semi-empirical models for vibration isolators, ballast mat and overhead conductors, are examples of demanding studies performed for industry. "Aeolian vibrations of single overhead conductors" has been one of the largest experimental research projects. This was a joint project with Tekes and industry (NK Cables). Another large experimental project was a field study on ice rubble strength properties.

Research quality

The unit produces an annual average of 1.6 articles in refereed journals, 6.1 articles in refereed proceedings or other volumes, 0.4 textbooks and other research-related publications, and 2.9 other scientific publications. The proportion of basic and applied research is about half and half. Almost 90 per cent of the research is theoretical by nature. The share of experimental work is smaller. Academy of Finland funding has an increasing trend, whereas EU funding is decreasing. The unit has a low PhD output. However, current PhD students are young and motivated. The unit is strong and known internationally for its work on ice mechanics.

Research environment

The unit has very good test facilities, in particular in fatigue testing, which are adequate to be able to conduct high-quality research. The equipment needs continuous upgrading and maintenance. This is not a problem for the unit.

Research networking and interaction

The unit has good collaboration with VTT, LUT and major industries. Short visits from the unit to institutions and industry in Poland and Italy, typically 2.5 and 1 months respectively, have taken place. Visitors from Greece, Canada, Italy and Germany have come to the unit for 1–3 months. In addition, short-term visits from other EU countries and the US have also benefited the unit. Important contacts with researchers from these countries have been established and these have resulted in joint publications.

Research on ice mechanics has included active national and international collaboration within EU- and Tekes-funded projects. The most important outcome of this collaboration has been the possibility to conduct and participate in large-scale experimental field programmes. The collaboration with industry (Metso Paper) and LUT has focused on paper rolling. The collaboration with the Cold Regions Research and Engineering Laboratory (CRREL) has been very important for research on the discrete element method (DEM). These collaborations have resulted in joint publications. Collaboration with a large number of Finnish companies has taken place during the evaluation period.

Recommendations

The group is motivated and has a strong background and potential to conduct basic research. The panel encourages the unit to establish a long-term vision and strategy to be successful and in demand in the long run.

The unit has been functioning as a teaching unit. As a result, the time and effort spent on research is too low; the situation has to be changed. The unit has researchers working on fundamental areas that are crucial to many other disciplines and corresponding units inside HUT. They should join forces with other units. Internal seminars should be conducted to explore the possibilities of collaboration and joint projects.

4.15 TKK Laboratory of Production Engineering

Overview

The HUT Production Engineering Laboratory is, since the recent reorganisation of the university, a research unit within the new Department of Engineering Design and Production (Faculty of Engineering and Architecture). The unit has two professors, twelve active research staff, of which two are PhD students, one laboratory manager and two technicians.

The unit's total funding amounts to about one million euros per year, distributed as follows: university budget 78 per cent, Tekes 7 per cent and industry 15 per cent. There has been no funding from the Academy of Finland, but a smaller amount (approx. €55,000 per year) of EU funding during the period 2002–2004. The number of staff has been stable over the period evaluated, while total funding has shown a slight decreasing trend.

Research profile

The unit's mission is to study and teach production engineering and to improve the competitiveness of the Finnish manufacturing industry. The focus of the Finnish industry's production has shifted from manufacturing and machining of parts to assembly, due to increased outsourcing of parts manufacturing. The strategy is to increase cooperation in Finland and internationally, with a shift to more scientific research. The unit has its strength in empirical research, but is planning to increase activities in modelling and simulation.

The unit's current research profile is focused on the following three fields: (i) Digital manufacturing including modelling and optimisation of production systems, control and programming of manufacturing processes (e.g. robots). This research is mainly directed to methodology and application of existing software, rather than development of new software; (ii) Machining and cutting (e.g. titanium, stainless steel, high-strength steel). This subfield, now directed to more modelling and software support, is considered the unit's focus area over the next five years. An example is FEM modelling of the cutting process in cooperation with material specialists, for instance, as well as cooperation with units specialised in forming and forging; (iii) New manufacturing technology (e.g. microelectrical discharge machining, micromachining, high-tolerance moulds, ultrasonic deforming)

Research funding and research activities within the field of tooling and moulds has recently vanished due to a changing industry structure, with much of tooling and moulding currently being outsourced to South East Asia.

Research quality

The unit's research is application-oriented; there is not very much basic research. The strength lies in empirical research. There are relatively few publications and in particular few journal papers. On average, there have been about seven publications per year, of which one per year in scientific journals. In addition, there have also been textbooks and similar publications, about 15 per year. Over the evaluated period, there has been only one PhD graduation (in 2006, with ten years for completion). The two PhD students within the unit have had very slow progress, due to many short-term projects for industry, as well as much teaching. There is no Academy of Finland funding and currently no EU projects in addition to the funding from Tekes and industry. There are, however, plans to improve this situation. Confidentiality has been a problem in applied research with industry, but this situation is gradually changing and publication can now often be negotiated with companies.

Research environment

Long-term funding will be necessary to conduct basic research, but the unit considered it difficult to obtain. The unit has as yet not succeeded in establishing a graduate school in cooperation with corresponding units at other universities (TUT, LUT and UO). A graduate school application has been submitted to the Academy of Finland, but it has not been approved. Presently, the unit has no graduate school positions.

The unit has, like many units in production engineering, a very high teaching load, with a large number of students: 200 major and 200 minor subject students. All students do machining laboratory work, which accentuates the staff workload. Unit staff supervise 18–26 MSc thesis projects per year. The teaching effort limits resources and the time available for research.

Students at the unit usually have little interest in PhD studies, due to very good career opportunities and salaries in industry. Industry opinion on PhDs is gradually changing, but, in many companies, it is still not so common to employ PhDs within the field of production.

The unit's laboratory facilities include relatively modern equipment: machine tools, for example for high-speed cutting, electric discharge machines, measuring equipment and an industrial robot.

Research networking and interaction

The unit does not report any international cooperation or visits, except for presentations at international conferences. National cooperation is currently limited to corresponding units at TUT, LUT and UO.

The cooperation with Finnish industry is, nevertheless, strong: for instance, Nokia was mentioned as an example. Industry cooperation is, however, mostly based on short-term commissions.

Recommendations

The whole unit can break down if Finnish industry increases its outsourcing, which has already happened in terms of tooling. The unit is therefore very vulnerable, as it relies entirely on short-term industry funding. The unit does not have a strong international scientific position. Increased scientific publishing and establishing of international research cooperation is strongly recommended. However, the unit is trying hard to establish more long-term scientific research. More focused efforts are recommended, as well as multidisciplinary cooperation within larger research programmes. The Academy of Finland and TKK should create programmes that are fundamental but also take into account the interdisciplinary nature of the field. They could start a new culture within production by funding a long-term position in a certain subfield.

4.16 TKK Ship Laboratory

Overview

The group consists of four professors. Among these, one professor is the Dean of the Faculty of Engineering and Architecture. There is a new professorship in marine traffic safety. Over the evaluation period, the laboratory had a total research staff average FTE per year of approximately 29. The budget funding is the main source of funding with an average of 58 per cent. Funding comes also from the Academy of Finland (2%), Tekes (11%), other public sources (4%), industry (11%) and the EU (11%). The total funding during 2000–2007 has been about 2.4 million euros per year.

Research profile

The unit focuses on ship and marine technology. It has selected the following main areas of interest from fields that have scientific, permanent and high societal impact in materials and structures: optimisation and decision-making in structural design, laser-welded structures; ship structures and their strength; in ship dynamics, large amplitude motions, mechanics of ship collision and grounding, stability of damaged ships, vibration and noise, and hydro-elasticity; in fluid dynamics, inaccuracies in propulsion power prediction, development of numerical methods in computational fluid dynamics (CFD), hydrodynamics of novel propulsion concepts, propulsion in ice; in safety of shipping, simulation of marine traffic and related risk analysis in the Gulf of Finland; ship-ice interaction; as well as reliability and use of ship machinery.

Research quality

The unit produces an annual average of 2.6 articles in refereed journals, 9.6 articles in refereed proceedings or other volumes, 7.4 textbooks and other research-related publications and 1.1 other scientific publications. New projects include the study of hydrodynamic loads on propulsion structures, fatigue of welded structures, thin ship structures, optimisation of ship structures, safety methodology and manoeuvring in ice.

The research group has the potential to make a significant impact within its research fields at EU and international levels. The unit is also prepared to follow the MeKo-SHOK agenda (Section 1.2). The proportion of basic and applied research is about 50-50. Almost half of the research projects are theoretical in nature. The rest have some experimental work component. Academy of Finland funding has shown a decreasing trend. Student enrolment has increased in recent times. The group needs more students with an applied mathematics background and tries vigorously to attract them.

Research environment

The unit has very good test facilities and, in particular, a large-scale ice tank and wave simulator, which are crucial to conduct high-quality research. The rental costs are high.

Research networking and interaction

The unit has good internal collaboration with other units and uses their facilities, and also collaborates with VTT. The unit has collaborative research activities with LUT, the Swedish School of Economics and Business Administration in Helsinki and with the University of Turku. Visits from the unit to institutions and industry in Poland, Netherlands, Denmark and the US, ranging from one to eleven months, have taken place during the evaluation period. Visitors from France, Japan and Croatia have come to the unit for 3–8 months. Important collaboration with researchers from other EU countries, Canada, Japan and the US has been established, and it has resulted in joint publications, theses, technical reports and courses.

Recommendations

The unit has impressive test facilities. However, it has not used these to produce high-quality research and for active publication so as to achieve international visibility and recognition. The panel is very concerned about this situation. The unit should work out a long-term action plan to correct this situation.

The unit has been focusing on applied research activities; the unit lacks basic research. It could have benefited significantly in this regard by collaborating with other units such as engineering mechanics units, fluid mechanics researchers, materials groups and other EU and international researchers. The unit has not done much in this regard. This situation needs to be corrected. The overlap in research should be avoided.

The unit relies heavily on industry, and industry problems will have strong influence on the unit. The unit should correct this dependence and have its own identity as an academic research unit. The unit can supply expertise and testing to other countries through strong collaboration at EU and international levels. This action will also bring more stability to the unit's function, without too much dependence on the Finnish ship and naval industries.

The unit lacks long-term vision and the leadership is close to retirement.

Continuity of research and preservation of strength should be achieved by mentoring and training of the next generation of leaders and researchers.

The unit is preoccupied with securing funding for infrastructure costs and rental costs. The level of funding could be raised by offering services to the international academic, scientific and industrial communities. The group should therefore allocate their time, resources and efforts to focus on basic research and on training more PhD students. They should also make good use of graduate school positions. A good balance between theoretical and experimental research should be achieved.

4.17 LUT Laboratory of Mechatronics and Virtual Engineering; LUT Laboratory of Fatigue and Strength

Overview

The unit consists of two combined laboratories: the Laboratory of Mechatronics and Virtual Engineering and the Laboratory of Fatigue and Strength, which represents the LUT Centre of Excellence in Research in Virtual Design of Intelligent Machine Structures and Systems (ViDIMS). ViDIMS is led by four professors. A fifth chair is planned in the area of machine design. With ten postdoctoral researchers and 14 PhD students, the centre currently has in total 28 researchers. The total funding during 2000–2007 was about 1.8 million euros per year, of which core funding covered 32 per cent, Tekes 32 per cent, industry 12 per cent, the EU 7 per cent and the Academy of Finland 7 per cent.

Research profile

The research group's focus is on modelling and simulation of complex non-linear machine systems with flexible structures, virtual design of intelligent machines and advanced robotic systems for welded structures, and in particular on modelling and analysis of machine dynamics using sophisticated models, active and semi-active vibration control and fatigue testing. The research spans from fundamental problems in flexible structure dynamics and fatigue problems in welded structures to more applied studies of robotic systems and different aspects related to new technologies for mobile machines with applications in the near future (3–5 years). The research group is involved in the European Union Fusion Project ITER by leading the development work of the fusion reactor vacuum vessel maintenance robot.

Research quality

The research activity of ViDIMS is exciting and impressive. The group has an excellent strategy with a clear profile and focus in a relevant and important area for Finnish industry. The unit is relatively small, but the quality of research is very strong. The group has continuously and very successfully built on its distinct expertise to increase research activities and output significantly. The number of PhD degrees awarded has increased and the number of journal publications and high-level peer-reviewed conference papers has also steadily increased over the last few years.

Research environment

The unit has nice facilities and well-equipped laboratories; some equipment requires replacement, however. The geographic location and the overall rank of the university limit the intake of local graduate students, but the group has been very successful in developing international programmes and networks for recruiting students. Currently, 30 per cent of the unit's researchers are foreign.

Research networking and interaction

The group has well-established national and international networks and cooperation. It participates in the graduate school CE Tampere (Concurrent Mechanical Engineering), which is coordinated by TUT. The group is also involved in several national and international research networks. One out of four research projects is a collaborative research project. One of the professors is Chair of the International Institute of Welding and an active member of the HRO (Optimisation of Welded Structures) design forum of the Finnish Welding Society SHY, the national welding network. The group has also much close collaboration with VTT.

Recommendations

The unit should aim to become a national Centre of Excellence. This would not only help in finding funding but also in attracting more excellent graduate students from Finland and abroad. The unit need help to improve the weak reputation of LUT and increase the attractiveness of the city. The unit needs to continue to apply for funding from the Academy of Finland to increase their fundamental work. They should also continue to publish their work in journals and at peer-reviewed conferences.

4.18 LUT Section of Production Engineering

Overview

Over the assessment period (2000–2007), the unit had an average FTE of approximately four professors, one senior researcher and three postdoctoral researchers, with a total of about 25 research staff. The group is relatively small, but has been actively collaborating with VTT and has many international contacts. The total funding over the assessment period was around 2.2 million euros per year, of which 1.7 million euros (76%) was external funding, mainly from Tekes (33%), industry (33%) and the EU (10%). Only a very small proportion of the funding comes from the Academy of Finland. The unit is responsible for teaching production engineering, machining, sheet metal technology, welding and laser processing.

Research profile

This is a well integrated research unit, with high-quality research in laser processing, welding and sheet metal technology. The main focus of the unit is on laser processing. This expertise makes the unit unique in Finland and places it among the top research units in this field on an international scale.

Most of the research work is based on industrial applications rather than fundamental research, with a focus on experimental developments. Due to the multidisciplinary nature of laser research, the unit collaborates with chemists and physicists from other groups at LUT and other universities.

Research quality

The number of journal publications is impressive: a total of 65 refereed journal papers in the assessment period, that is, an average of 8.1 journal papers per year. In addition, 209 conference papers were published and eight patents were registered, which is a good indication of the level of innovation in the research.

There were six PhD completions in the assessment period (2000–2007), which is considered low for a high-profile research laboratory. This is due to the fact that Tekes funding for the PhD students is partial, and some of the industrially funded work does not appear in the PhD theses. More funding from the Academy of Finland would provide a stable environment for PhD students and more innovative fundamental research activities.

Recruiting high-quality PhD candidates from local regions has been difficult, which may result in more active recruitment of international PhD students.

Research environment

There is good investment in experimental facilities, including machining and turning equipment, industrial robots and sheet metal equipment. There are excellent laser processing facilities, with some equipment shared with VTT. There are sufficient funds to maintain and enhance the current equipment.

Research networking and interaction

The unit is actively involved in many national and EU networks related to laser processing. In particular, there is close collaboration with VTT, and a high level of national collaboration with other universities in Finland (TKK, UO and the University of Joensuu). There is a moderate level of activity in visiting other institutions outside Finland and in visits to the unit from abroad. However, there is a high level of participation in editorial boards, scientific and professional committees, which reflects the high professional standing of the staff.

Recommendations

The panel is impressed with the high quality of the research in laser processing and the investment in facilities shared with VTT. The quality of the research is evident from the high number of journal publications in highly regarded journals. The panel recommends that more conference papers be converted into journal papers. Joint ownership of equipment with VTT has been mutually beneficial and should continue.

In the light of the difficulties in recruiting and retaining good PhD candidates, the unit should devise better funding mechanisms and better career progression policies for contract staff. Active recruitment of international PhD students should also be considered. The unit should also use creative laser displays as a means of promoting awareness of science and engineering through open days and public events.

The panel suggests that research expertise and knowledge be shared within the unit. This can be achieved through a targeted programme of internal workshops and seminars to encourage more internal collaboration and promote new ideas for more fundamental long-term research proposals. The unit would also benefit from recruiting material scientists and investing in material characterisation research.

4.19 LUT Laboratory of Wood Technology

Overview

The Laboratory of Wood Technology is placed within the LUT Department of Mechanical Engineering. The group is led by three professors (since 2002, reduced to two since 2007) with one senior researcher (until 2006), one postdoctoral researcher (since 2005), two other academic staff and eight PhD students, supported by three technical staff. Total funding over the period 2002–2007 was 0.7 million euros per year including 0.5 million euros external funding mainly from industry. The unit is one of the two wood technology research groups in Finland.

Research profile

The unit's research areas include methods of further processing of wood, wood working techniques, machines and tooling technologies, wooden boards (veneer, laminated veneer lumber, glued solid wood) and composites (wood-plastic composites, agrofibres and fillers, started in 2004). The strength of the unit is its multidisciplinary expertise including chemistry, forestry, mechanical engineering, materials and design. Research is mainly driven by industrial needs and most projects are application-oriented by nature.

Research quality

The unit has produced eleven journal papers, 21 conference papers and two national patents during the period 2000–2007. These numbers are relatively low compared to similar research groups in developed countries. There were no PhD completions during the evaluated period. One spin-off company, CWP Oy, on coloured wood products, has started based on the work by the unit and three industry-related patents (two produced during the assessment period) are being used by companies.

Research environment

The unit has invested 2.2 million euros in research equipment during 2002–2007. There is still an urgent need for testing facilities. The unit has trained 56 MSc graduates and unit staff have provided 15 different lecture courses.

Research networking and interaction

The unit collaborates with a good number of companies and universities in various countries including Russia, Austria, Hungary, Sweden, Norway, Germany, Canada, Sweden, France and Estonia. Most of the collaborative projects run for more than one year.

Recommendations

The unit needs to apply for more funding for urgently needed testing equipment. The unit needs to be more proactive in gaining public funding for fundamental research. Also, the unit needs to increase the number of PhD graduates and journal publications. Improving publicity and marketing to increase the international visibility would also benefit the unit. Finally, the unit needs to be more focused on its strong areas to deepen its expertise.

4.20 TUT Department of Intelligent Hydraulics and Automation

Overview

The department has six professors, ten senior researchers, 50 researchers and 25 research assistants. The department consists of three major groups: Fusion, Digital Hydraulics and Intelligent Control of Mobile Machines. The department is one of the five largest departments in fluid power worldwide. The number of foreign researchers has grown continuously. The department has been a Centre of Excellence between 2000 and 2005. In 2008 it was re-appointed by the Academy of Finland as the Centre of Excellence in Generic Intelligent Mobile Machines (GIM). The centre is formed together with the TKK Laboratory for Automation Technology.

The total average funding in 2000–2007 has been about five million euros per year, of which core funding covered 54 per cent, Tekes 21 per cent, the Academy of Finland 8 per cent and industry 7 per cent.

Research profile

The department conducts research in the field of fluid power, mainly in hydraulics. One of the areas of expertise is water hydraulics, where substantial contributions to the advancement of state-of-the-art component and system design have been made over the last two decades. This research is now continued in two groups: the fusion group and the digital hydraulics group. Mobile hydraulics forms the core research field of the department. Most of the research is applied and focused on mobile hydraulics.

Research quality

The research team is very enthusiastic and ambitious. The impact of the research on fluid power and machine design is remarkable, both in the scientific community and in industry. The department has strong international collaboration with other research teams in fluid power and machine automation and very strong collaboration with Finnish and international industrial companies. The team is a member of the Network of Fluid Power Centres in Europe FPCE and a member of Fluid Power Net International – a worldwide scientific network in fluid power.

The research team is led by outstanding researchers who are internationally known for their leadership in the field. The unit has an excellent strategy with a clear profile and focus and a well-defined vision. All research teams of the department are very visible internationally and strongly engaged with other leading groups worldwide. The unit organises and hosts a well-established international conference in fluid power every four years.

The department generates an appropriate number of Master's theses. However, the PhD production is relatively low. The unit has a good number of excellent conference publications. The number of journal publications is low compared to international standards.

Research environment

The unit has world-class research facilities for both high-quality theoretical and experimental research. The strong cooperation with industry, the excellent leadership and the long experience guarantee sufficient funding to maintain and further expand the group. The machine test facility is very impressive and forms the basis for the planned research activities within the new established Centre of Excellence in Generic Intelligent Machines Research (GIM).

Research networking and interaction

The unit has very good international collaboration with leading teams in several fields of fluid power and machine automations worldwide. The unit has initiated collaboration with France, the UK and China, not only with the aim of research cooperation but also to attract new postgraduate students. The unit has outstanding networks and partnerships with the fluid power industry and vehicle and machine manufacturers. The involvement in research programmes funded by the EU is impressive.

Recommendations

The unit should strengthen PhD training to increase the number of high-quality PhD theses. While continuing to have a well-balanced research portfolio, between fundamental and applied research, the unit needs to put more emphasis on journal publication.

4.21 TUT Department of Mechanics and Design

Overview

This is a new unit, formed in January 2008 by combining the former institutes of Machine Design as well as Applied Mechanics and Optimisation, and by adding one energy engineering chair. The unit is relatively large, with an average FTE of approximately six professors and a total of 40 research staff.

The unit is one of the core departments in teaching mechanical engineering degrees responsible for degrees in machines and design. It is also responsible for administering the national Graduate School in Concurrent Mechanical Engineering. Teaching commitments have increased over recent years, resulting in less time being devoted to research activities.

The total amount of funding over the assessment period was around 3.2 million euros per year, of which 1.3 million euros was external funding. The external funding for research comes mainly from Tekes (11%), industry (17%) and the Academy of Finland (4%). The self-assessment report and the analysis of the strengths and weaknesses of the unit are not very comprehensive due to the recent formation of the unit. However, the process of reflective evaluation has been underway since the formation of the unit in January 2008, and will be completed in October 2008.

Research profile

The unit has seven professors working in the fields of machine dynamics, maintenance engineering, power transmission, elasticity and optimisation, mechanics, virtual technology and process engineering. The research work is mainly of an applied nature, largely driven by the needs of the industrial sponsors.

The research work is of a high quality and there is a good balance of experimental and theoretical work. Compared to other similar units in Finland, this unit is quite successful in securing funding from the Academy of Finland.

Research quality

The quality of the research work is clearly reflected by the high number of international journal publications, with a total of 58 refereed journal papers, that is, an average of 7.3 journal papers per year in the assessment period (2000–2007). In the same period, 309 conference papers were published and seven patents produced. The research output at conferences is much higher than the output in refereed journals.

There were 16 PhD completions in the assessment period, with a high proportion of PhD graduates employed in industry. The time to complete a PhD far exceeds the optimum period of four years. This has been caused by the lack of continuous funding for PhD students, resulting in many PhD students working on short-term projects in order to secure funding.

The funding from the Academy of Finland has been very beneficial in increasing the rate of PhD completion, resulting in more external journal papers in leading journals.

Research environment

The unit has good experimental facilities, which include full-size dynamic and fatigue testing equipment, a two-roll press for testing the dynamic contact of rolls and a counter-flow laboratory mixer for soils and granular materials. The unit appears to have sufficient funds for maintaining the current facilities.

Research networking and interaction

There is a high level of national collaboration with VTT and other universities in Finland (TKK, LUT and UO). There is a moderate level of activity in visiting other institutions outside Finland, such as in Germany, the UK and Australia, and a few visits to the unit from abroad. Participation in scientific committees and editorial boards is at a good level.

Recommendations

The panel recommends that the unit develop, as soon as possible, a long-term research strategy for the new grouping of staff. The strategy should be inclusive of all research activities in the unit, with the main objective of achieving better integration of machine design, engineering mechanics and process engineering. The unit should consider how to develop and market a new identity, and how to build critical mass around new ideas.

The number of external journal publications should be increased with an increased proportion of journal to conference publications. The unit should also address ways of reducing the current high teaching load.

On an international scale, the unit would greatly benefit from increasing the level of fundamental innovative research, without necessarily aligning the work to the short-term needs of industry. More fundamental research proposals should be submitted to the Academy of Finland, and more mathematically-oriented PhD candidates should be recruited to work on new challenging projects.

4.22 TUT Department of Materials Science

Overview

The TUT Department of Materials Science is part of the Faculty of Automation, Mechanical and Materials Engineering within the university and is one of the oldest departments (started in 1968). The department has eleven professors, two senior researchers, two postdoctoral researchers, 65 postgraduate students (mainly MSc) and 47 other academic staff, making the total research staff 125, supported by four administrative staff and seven technical support staff. The department's funding stands at 6–8 million euros per year, consisting of core funding (29%) and external funding (more than 70%) including industry (20%), the EU (4%) and Tekes (24%).

Research profile

The research in the department covers almost all types of materials including metallic, ceramic, polymer, composites and natural materials. About 80 per cent of the research is focused on materials technology and 20 per cent on manufacturing. Research areas include ceramics surface engineering, joining technology, failure analysis, coating technology, behaviour of materials (e.g. tension, compression, high strain impact loading and fatigue), foundry technology, graded and functional materials, electron microscopy, fabrication technology, plastic and elastomer technology, corrosion and erosion, and laser applications. 75 per cent of the research is experimental and applied by nature.

The department's research is of world class with high strain rate applications, unique and strong research in porous and high temperature ceramics at both macro-, micro- and nanoscales. In the area of plastics and composites, about one third of the researchers are working within nanomaterials.

Research quality

The department on average publishes 17 journal papers and 28 conference papers per year and has produced a number of patents. This, although relatively high compared with other mechanical engineering disciplines, is still low considering number of research staff and compared with research science departments in other developed countries. As most research projects are application-oriented, the number of PhD graduates is relatively low (23 graduated in eight years, i.e. less than three per year). The department is responsible for the graduate school in polymer materials. This should help in getting more PhD training opportunities.

One member of the department belongs to editorial boards of international journals and there have been two invited lectures at international conferences over the last eight years.

Research environment

The department has advanced and unique high strain rate testing facilities. Also, the department has facilities for extrusion, polymer engineering and composite engineering and laser surface treatments. The department has standard material characterisation facilities including scanning electron microscopy, scanning transmission electron microscopy, atomic force microscopy, X-ray diffraction, differential scanning calorimetry and scanning tunnelling microscopy (SEM, STEM, AFM, XRD, DSC and STM), most of which are aged and need upgrading. Recently, the department has installed a new FEGSEM (Field Emission Gun Scanning Electron Microscope). The material testing and fabrication laboratories are located in five different cities. Therefore, while the professors are working mainly at the university, most senior researchers need to work in other places.

The department provides training for MSc students with typically 35 students per year. The professors of the department have a high administration load, with one professor being Vice Rector of the university, and one being a faculty Dean. The professors spend most of their time writing research proposals and little time is available for direct research and writing research papers. The staff workload distribution varies, with typically 20 per cent research, 50 per cent administration and 30 per cent teaching.

Research networking and interaction

The department has research collaboration with physics and production technology departments. Industrial collaboration is very strong with typically 50–150 companies. The department has bilateral agreements with various European countries within the EU Socrates programme for education and training. Research collaboration with VTT as well as with other European countries has been very strong. Also collaboration with the US has been established.

Recommendations

The panel encourages the department to actively develop a national network and explore more interactions with mechanical and production engineering. The panel recognises the wide range of research subjects covered by the department. A strategy needs to be developed to focus on a few more promising areas. The department needs to develop a strategy for attracting talented young people and retaining them until they graduate. Also, the department needs to develop a strategy for improving publication rates and PhD student numbers. Finally, the department needs to carry out a strategic review of research and facilities to enable more balanced basic and applied research and infrastructure.

4.23 TUT Department of Production Engineering

Overview

The TUT Department of Production Engineering has six professors and one vacant chair, eight senior and postdoctoral researchers, five other academic staff and 29 postgraduate students; many of these are employed by industry. Master's students are employed as research assistants. TUT is located in the gravity centre of the Finnish manufacturing industry, and the size of its departments is proportional to the industry's demand for employees. Teaching and research cover both production and design.

The unit's total funding amounts to about 4.5 million euros per year, distributed as follows: university budget 38 per cent, Academy of Finland ≤4 per cent, Tekes 36 per cent, EU 14 per cent and industry 8 per cent. The number of staff has been stable over the last seven years and total funding has increased considerably.

The department cooperates with other Finnish universities and with VTT, concerning production technology. The units have different profiles and do not have overlapping functions. TUT is by far the largest unit, with main emphasis on assembly, while TKK's focus is on mechanical manufacturing, LUT's on sheet metal production and laser technology, and UO's on accurate small-piece manufacturing.

Research profile

The unit's vision is multidisciplinary research on flexible small-batch and IT-supported production, in cooperation with international research, to support the competitiveness of the Finnish manufacturing industry. The long-term research objectives are knowledge-based (digital and adaptive) manufacturing and rapid adaptation of new technologies in networks within the Finnish manufacturing industry.

The unit's research is mostly applied and the current research profile includes the following areas: (i) manufacturing technology: cutting, laser processes, assembly systems, flexible manifacturing systems (FMS), micro-manufacturing, a leading and nearly commercialised area ahead of competitors and with applications in areas such as medical implants and small mechatronic devices; (ii) factory automation: information systems, robotics, machine vision, automated assembly lines and distributed diagnostics; (iii) quality techniques and measurements; (iv) product development: design methodology, product structure, modularisation, PDM/PLM (Product Data/Lifecycle Management) systems engineering and risk management; and (v) product realisation: integration of the entire product-manufacturing processes-production system chain.

Research quality

The panel considers the unit comparable to world-class production research units. Funding by Tekes and industry – shorter projects – dominates. There are also a number of ongoing EU projects. Academy of Finland funding has virtually vanished over the last years.

So far, publications have mostly been conference proceedings, as is typical for the field. The conference papers are, however, considered to be of a high quality. The number of journal publications has been increased over the last three years (5–8 per year). The number of PhDs completed is moderate but improving; ten PhDs graduated in the last two years.

The laboratory is strong in many areas, for example in micro-manufacturing, ICT in manufacturing and modularisation of products and production systems. One national patent is reported. The department is certified according to ISO 9000, since 1998 – at the time the first certified university department in Europe.

Research environment

The unit's laboratory equipment is getting old and there is an obvious need for new investments in machine tools (used also for education). The laser laboratory is in need of heavy investments. Regional cooperation (facility sharing) may be helpful. The teaching load is high, but students are hired for teaching.

With the size of the unit and the variety of research subfields, staff expressed concern over a problem of internal communication and a risk of overlapping parallel activities.

Research networking and interaction

There are very strong links to the Finnish industry sector, as well as to many companies elsewhere in Europe. The unit cooperates with other Finnish universities (TKK, LUT and UO) and with VTT in the field of production technology.

The unit has also a comprehensive international academic network, with project cooperation in Sweden, Germany, the Netherlands, Hungary, the US, Singapore, Argentina and Mexico. The unit's participation in EU projects is increasing.

Professors are members in editorial boards of scientific journals and boards of international design conferences.

Recommendations

The panel considers the unit comparable to world-class production research units. A definite strength is the unit's integration of product development and production.

The panel recommends that the unit increase the number of journal publications and PhD completions, as well as further emphasise international cooperation – not only in EU projects. Also, the research should be more directed to fundamental research as a basis for innovation. With the current high number of short-term research projects closely related to industry needs, the situation is vulnerable to possible outsourcing of manufacturing from Finland. The possibility for more outsourcing of mechanical manufacturing from Finland is considered a major threat. Production research must therefore look ahead to introduce new manufacturing technology and methods, in order for Finnish industry to maintain its competitiveness.

The facilities are slightly out of date and investments in new equipment are needed. As regards laser equipment, joint investments or cooperation with VTT, LUT and possibly foreign research groups is seen as a possibility.

4.24 TUT Center for Safety Management and Engineering

Overview

The Center for Safety Management and Engineering is part of the TUT Department of Industrial Management. The centre has two professors, 15 active academic staff and eight PhD students. The scope is wide, but closely related to mechanical engineering.

The unit's total funding amounts to about 0.9 million euros per year, with funding coming from the university budget (78%), the Academy of Finland (5%), Tekes (<0.5%), other public sources (15%) and industry (2%). There are currently no ongoing EU projects; some EU funding was obtained up to 2000. The number of staff has been somewhat decreasing over the period evaluated, while total funding has been fairly stable.

Research profile

The unit's mission is to conduct and provide research and education to improve safety and the environment, and hence to improve competitiveness and well-being within industry, production and products, services and retail.

The current research profile includes (i) safety ergonomics and usability in design; (ii) hazardous environments; (iii) risk management, risk assessment and safety information systems; as well as (iv) environmental management and life cycle design.

Examples of current projects include reduction of vibrations to drivers of working machines to fulfil EU directives; use of a national accident/disease database; electrical safety; safety in potential explosive environments (with VTT); and safety improvement in SMEs.

Research quality

Besides comprehensive and continuous cooperation with Finnish partners, the unit also cooperates with other European partners (ILO and European Agency for Safety and Health at Work) as well as experts in the field of safety management and engineering. The unit's research field is quite diverse, but the unit seems to keep the activities well together. Publication is mainly directed to journals, with about three journal publications per year over the period evaluated. The unit aims to increase journal publication. PhD completion has so far been moderate but stable, with an average of one graduation per year over the evaluation period.

Research environment

External funding comes primarily from the Finnish Work Environment Fund (usually 1–2-year funding), which is not always easy to combine with PhD studies. At present, the unit also has one project funded by the Academy of Finland. The centre has a small laboratory for user studies and measurement of muscle activity, related to the product development of handheld equipment. Software is available for anthropometry and biomechanics (primarily for teaching), for instance. More comprehensive experimental research including testing of user interfaces and human interaction of stationary equipment is carried out in other laboratories. The unit's staff have a fair balance between research and teaching. The teaching load is high, as basic courses are given at all faculties. Another problem is the high turnover of staff.

The centre has a good number of PhD students; there are currently two PhD students in graduate schools (funded by TUT). Two PhD students are assistants at the centre and there are four PhD students in externally funded projects. The staff feel that it is easy to recruit PhD students within the centre's fields of research.

The centre has a very positive gender distribution, which is unusual within mechanical engineering in Finland.

Research networking and interaction

The unit has a comprehensive national and international research network. In Finland, major partners include VTT, the Finnish Institute of Occupational Health, the Federation of Accident Insurance Institutions and relevant ministries. There is also some cooperation with UO.

International research collaborators include ILO-Switzerland, the European Agency for Safety and Health at Work, and the Universitat Politècnica de Catalunya.

There are also direct industry research contacts, for instance with Fiskars concerning development of cutting blades for handheld tools.

Recommendations

The unit is quite strong. Its research is targeted at the interactions between technology development and societal needs. The environment and safety are becoming issues of major importance and these aspects must in future be integrated into all applied technology, product and production research and development, for companies to stay competitive. Hence, the centre has good potential for further development. Its capabilities should be useful for and included in, for example, the GIM project on automation. Improved cooperation with units in product development and design, as well as in production, would therefore open further possibilities and is recommended. The panel recommends that the unit seek continued funding from the Academy of Finland to state the importance of this field and to guarantee long-term research and sustained PhD student funding.

4.25 VTT Industrial Systems Knowledge Cluster

Overview

VTT Technical Research Centre of Finland is the largest research institute in the Nordic countries and has facilities in ten Finnish cities. It provides technological research, development and testing services to the private and public sectors. Since its founding in 1942, VTT has undergone several organisational changes that primarily have joined smaller units together into larger entities. In 1994, the 39 laboratories and four divisions of VTT were replaced by nine independently accountable research institutes, two of which were VTT Automation and VTT Manufacturing, which were then further combined into VTT Industrial Systems in 2002. The organisation was changed in 2006 to a matrix type in which VTT Industrial Systems is one of seven Knowledge Clusters. The review for this unit covers the period 2002–2007.

VTT Industrial Systems is a world-class research unit with an international reputation in intelligent systems and materials processing technology. The unit has 255 FTE workers and 68 per cent are research staff (three professors, 143 senior researchers and 26 postdoctoral researchers), all of whom hold permanent posts, providing a stable critical mass (largest research unit in Finland in the above areas) in industry-driven research in industrial systems. The research teams are supported by 58 technical support staff and 23 administrative support staff. Research income varies between 22 million euros in 2002 and 30 million euros in 2007, with 30 per cent being government core funding and 33 per cent industry funding. VTT has established itself in the top 2 on the list of the most attractive workplaces for engineers in Finland.

Research profile

The main research areas of the Industrial Systems Knowledge Cluster are encompassed by six knowledge centres: virtual models and interfaces, smart machines, production systems, advanced materials, systems engineering and vehicle engineering. Of these, the most prominent areas are materials for noise and vibration control, service-based business, fluid structure and interaction, materials processing, materials engineering (e.g. applications of shape memory alloys). Application of material technology in new areas is a strong field of research.

VTT has five types of research: 1) frontier technologies that aim at finding new emerging technologies and their potential (usually short-term, 5% of total core funding and 3% of total research volume); 2) strategic technology themes that aim at meaningful technological breakthroughs and at creating networks with leading international research groups (1–5 years, 20% of total core funding and 9% of total volume); 3) key technology actions that aim at innovations that have great, rapid business potential (20% of core funding and 15% of volume); 4) research consortia (55% of core funding and 40% of volume); and 5) customer projects (0% of core funding and 33% of volume). Basic research accounts for 30 per cent and applied research for 70 per cent of the activities.

The unit has some high-profile projects, such as the ROVIR project, where a mock-up of the ITER fusion reactor has been built to study the methods of automation and control for maintenance of the reactor. In general, the experimental part of the research is partly being replaced by simulations. However, the unit seems to be aware of the value of also keeping the experimental part of the research vital. The key strengths of the unit are in intelligent machines and vibration control, manufacturing and materials. The unit has a clear research strategy governed by the Finnish industrial needs of today and tomorrow (e.g. consideration of energy and environmental issues as the new requirements for products and production processes).

Research quality

The unit carries out a large number of industrial projects, which translates into a limited opportunity for publication. The number of conference publications is on a fair level (on average 53 per year over the assessment period), whereas there does not seem to be a high number of publications in peer-reviewed journals (on average 20 per year, about 0.1 per FTE). The unit has noticed the issue and taken actions to improve the situation, for example by setting target publication rates for researchers. This has resulted in an increasing trend in the publication rate over the last few years. Particularly the publications on advanced materials and smart machines are of a high quality.

The international visibility of the unit is high. Members of unit have been invited to serve as members on editorial boards of 13 international journals. The unit has produced a high number of text books and monographs (10 per year), but with a relatively low number of patents (on average less than 3 per year). A separate entity, VTT Venture, is responsible for IPR protection including patents and copyrights and marketing.

Research environment

In staffing, the turnover of young scientists is 7 per cent per year, compared to up to 25 per cent for the electronics area at VTT. However, a large number of the staff is retiring soon and there are worries about recruitment. VTT has in place mechanisms for monitoring staff performance and provides internal training schemes for staff. VTT is prepared to use its own money to achieve critical mass in important fields. The total number of research-active staff has been increasing slowly during the last five years. The current state of the industry gives rise to new opportunities – industry has healthy order books, showing a 26 per cent increase from 2006. The industrial workforce is therefore on the increase. This can also be a threat, since it reduces the pool of available talented research staff.

The computers and software are up-to-date and the unit invests one million euros per year on infrastructure. In the case of some facilities, fatigue testing and spraying for coatings for instance, the equipment is ageing. The unit is ISO 9001:2000-certified.

The world-leading machine industry players are based in Finland and wish to stay in Finland. There is willingness in the industry to increase automation in manufacturing and the unit is well placed to take advantage of this opportunity. VTT also plays a role in providing the infrastructure to keep Finland attractive to companies.

The unit does not have right to grant degrees, but over the period 2002–2007, 13 of its researchers completed their MSc and 15 researchers their PhD degree at universities. It appears that the unit is not highly motivated in terms of doctoral education.

Research networking and interaction

About one in three of the unit's projects are run in collaboration with other knowledge centres within VTT. The unit actively participates in EU networks, EU technology platforms and EU working groups (e.g. the EU 'Manufuture' Technology Platform). The unit has strong collaboration with industry, national universities and international organisations. For example, it collaborated with 470 companies in 2007. The unit has 20 joint appointments with other organisations (universities and companies). It has active collaboration with many countries, particularly in Europe. The unit reported visitors to the unit from a number of countries, mostly from EU countries.

The unit has conducted symposiums, conferences and workshops of a technical nature. The unit does not have a strong connection with the general public and does not consider this to belong to its core missions.

Recommendations

The panel encourages the unit to put more effort into the training of PhD students in collaboration with universities and in addition to put in place sufficient resources and infrastructural support to enable students to complete their PhD programmes on time. This would provide good opportunities for recruitment and journal publication.

The panel encourages the unit to improve its journal publication rate and patent applications. The current amount of core funding is healthy to retain stability. The panel feels that there is an opportunity to increase the ratio of external funding compared to core funding, which would allow the unit to expand its activities, invest in new infrastructure and participate in a greater number of projects.

Programmes such as internal workshops for cross-collaboration within the VTT are recommended to network with people from within VTT. The unit is encouraged to maintain a healthy ratio of experimental work and simulations. The panel recommends that the unit consolidate its world-class strong areas and become more visible in these areas. VTT is an industrial research organisation and should operate and be assessed differently from university research groups and the unit is encouraged to look into developing procedures for and participating in the industrial research evaluation matrix with key performance indicators specific to the nature of the research.

4.26 UO Engineering Mechanics Laboratory

Overview

The Engineering Mechanics Laboratory of the University of Oulu includes both engineering mechanics and structural engineering. The group consists of two professors, twelve staff, 25 MSc students and ten PhD students. The average total funding in 2000–2007 has been about 0.6 million euros per year. Budget funding is the main source with an average of 76 per cent. Funding comes also from the Academy of Finland (11%), Tekes (5%), other public sources (2%), industry (5%) and the EU (1%).

Research profile

The main areas of research are vibrations of axially moving materials; mechanics of composites; mechanics of smart materials with focus on medical applications; development and assessment methods for structural resistance and serviceability criteria for existing structures with high risk of human losses; and mechanics of composite structures with focus on shallow profiles. Faculty and staff have a high level of scientific experience. Good contacts and collaboration with industry have been achieved.

There is no long-term research strategy for the unit. However, as far as the research strategy is concerned the unit has identified the industrial relevance of its research areas, and that these areas can benefit from interdisciplinary collaboration (e.g. with the medical field, optoelectronics etc.). The unit has potential to make a significant impact in the field at EU level. Developing codal provisions and contributing to Structural Euro codes have been among the objectives of the unit's research activities. The unit also participates in national standardisation committees as well as national and EU technical committees and expert groups.

There has been a steady decline in the funding from Tekes and the Academy of Finland. Industry funding has been unpredictable and has varied considerably in the past. Overall funding is declining and the number of research staff has decreased. Also, too many tasks have been assigned to the staff and there is no strong leadership.

Research quality

The unit produces an annual average of 2.6 articles in refereed journals, 3.9 articles in refereed proceedings or other volumes, 0.1 textbooks and other research-related publications and 2.3 other scientific publications. The number of other scientific publications is almost of the same magnitude as that of journal publications; these are mostly technical publications. Among them, some are refereed, and some are not.

The group has made very good contributions to both basic and applied research in the past. It has also developed a very good test facility. However, recently, due to budget cuts, it has had to downsize the laboratory facilities as per the university's decisions, which has caused some problems.

Research environment

The unit has very good test facilities that are adequate to be able to conduct high-quality research. Previously, the facilities were owned by the university. Now, they have been handed over to a company to be taken care of. It has not been possible for the unit to plan its financial situation. Due to administrative decisions, the unit has had to give up on keeping the test facilities. The group is disorganised and staff morale and motivation are at an exceptionally low level.

Research networking and interaction

The group has identified and demonstrated potential for multidisciplinary research. The unit has good internal interdisciplinary collaboration with other units at UO, especially with the Faculty of Medicine. Such collaboration has resulted in journal papers and licentiate theses. Some foreign collaboration activities have been achieved, with one each from the Czech Republic, Hungary, the US and Sweden. These have resulted in theses and papers. Good industrial collaboration with Finnish, Swedish, and German companies has also been established.

Recommendations

The panel recommends that the group make every effort to collaborate with other units and make contributions to interdisciplinary research that can lead to more publications and graduation of PhD students. Dependence only on industry support should be reduced and support from the Academy of Finland and Tekes pursued more vigorously. The need to have new chairs and professors is urgent and efforts to address this need should be made as soon as possible. The test equipment needs to be upgraded through strategic planning and prioritising.

The unit should have positions at a graduate school and basic research must be conducted by the students funded by the graduate school.

There are two subgroups, one belonging to the structural engineering area and another to engineering mechanics. They have been working on totally different research projects in the past, which has created internal problems. The unit should try hard to identify common interests and capabilities, as well as complementing expertise. They should work on new projects that can benefit from these and avoid overlapping in their research activities.

There is a leadership vacuum and no vision, motivation or enthusiasm. The university has to address these serious problems with top priority. There is an urgent need to bring in new professors to the unit.

The group has serious concerns about the future of the unit. Leading researchers are close to retirement and senior researchers are close to the end of their contracts. This has affected the morale and motivation of the entire unit. An acceptable level of job stability should be provided to the members of the unit.

4.27 UO Laboratory of Process Metallurgy

Overview

The unit (also known as PYOMET) is placed in the Department of Process and Environmental Engineering of the University of Oulu. It also belongs to the Centre for Advanced Steels Research (CASR, part of the Oulu city innovation strategy, established in 2006) and to the Centre for Industrial Residue Utilisation. It has one professor whose chair was first funded by industry in 1991. Since 2000, the unit has grown to 2–3 senior and 2–3 postdoctoral researchers. Postgraduate student numbers have varied between six and nine. The age profile of the staff is mixed. The unit has a very good range of experimental facilities and access to microstructural characterisation facilities. As part of the Department of Process and Environmental Engineering it has received two awards for excellence in education. Its total funding during 2000–2007 was about 1.4 million euros per year. Funding, as a percentage of total funds, has come from industry (41%), Tekes (26%), budget funding (22%), the Academy of Finland (7%) and other public sources (4%). Funding from the Academy of Finland shows an increasing trend, in comparison to the decreasing funding from Tekes, which, however, is perceived by staff as being crucial for the future of the unit. The unit is working hard to get EU funding.

Research profile

The mission of the unit is to conduct high-quality metallurgical and other high-temperature processes research and to produce graduates who understand and master the phenomena associated with high-temperature processes.

The research themes are reduction metallurgy, refining metallurgy and environmental engineering at high-temperature processes. About 30–40 per cent of the research is fundamental. The key technology areas on which research (and education) is built are thermodynamics, kinetics, macro- and micro-mass transfer, heat transfer, and applied petrology and mineralogy. Material engineering, control and automation engineering, process engineering and industrial environmental engineering are used as additional competencies.

The unit has managed to establish a distinct position in terms of chemical metallurgy research in Finland. The most important contributions of the unit have been in fluid flow modelling, blast furnace metallurgy, secondary steelmaking metallurgy and refractory materials research. Research tools that are utilised and developed include different experimental methods, numerical and physical fluid flow modelling including CFD (computational fluid dynamics), and thermodynamic modelling. The focus on steels is a great strength as well as a weakness of the unit.

Research quality

The unit is a very good chemical metallurgy group with the potential to improve significantly its international visibility if its size were to increase. The size of the unit is of concern, especially since young staff tend to move. The latter has an effect on the visibility of the unit at international conferences and on its efforts to attract EU funding. The unit's research has quality and originality and the industrial impact is significant. Increased funding from the Academy of Finland is having a positive effect towards improving the academic impact of the unit's research. The latter will be assisted by its participation in CASR and the collaboration of the latter with overseas Centres of Excellence.

The publication record is very good considering the size of the unit and significantly better compared to that of other units. There is a good tradition in publishing peer-reviewed papers in the established journals of the field and the publication record is improving steadily. The number of PhD students is high when compared to other units but low compared to overseas materials research groups. The size of the unit has an adverse effect on publications and PhD student training.

Research environment

Much time and effort is spent on providing services to industry and raising much needed funds to keep staff. The non-human resources are adequate; emphasis on science and fundamental research is improving within a framework of activities that try to balance the staffing requirements and industrial funding with academic priorities.

Educational and administrative loads are just manageable given the size of the unit and PhD students often have difficulties finalising their work and submitting a thesis, owing to financial constraints. The professorship is now an established university chair. However, career progression opportunities for well-qualified staff are not in place at the university and this could threaten the viability of the unit.

Research networking and interaction

The unit is just managing to network with other groups in Finland and Nordic and northern EU countries, but its international networking and collaboration suffer because of its small size. Interaction with Finnish industry is improving.

Recommendations

Exploit opportunities for even closer collaboration with the Materials Engineering Laboratory at UO (unit 29 in this evaluation) and the CASR partners and develop tactics to improve international collaboration and networking. Redefine strategy to gradually diversify research from its main emphasis on ferrous chemical metallurgy and plan for long-term research with an emphasis on innovation.

4.28 UO Machine Design Laboratory

Overview

The unit has two professors, no post doctoral researchers, three PhD students and a few other staff. There is a limited amount of time for research in the areas of general machine design and paper machine design. The unit has a strong focus on education and industrial collaboration. This is also reflected in the funding, where the most is core funding (82% of about €0.6m per year in 2000–2007). There is some Tekes funding, and some from industry. Recently, the unit also had EU funding.

Research profile

The laboratory has decided to concentrate mainly on the following research areas: design methodology, mechanical vibrations, machinery of paper industry, automotive and mobile production machinery, and energy.

The aim of the research in design methodology is to find formal methods for capturing the requirements of a multi-technology product into a functional state transition model, which can be used as a foundation for the computer-aided design process.

The other major research area is vibrations. The most important applications are in paper production machinery. The other areas seem to have very limited research activity at present.

Research quality

The unit's approach to research is reasonable. However, a great deal of the work is more product development than research. The scientific output from the unit is quite low. The unit has no refereed journal papers and only a few conference papers. One explanation is that the area of paper machines is a speciality of the Nordic countries and there is a very small scientific community and only a few scientific journals.

On the other hand, there is a fair number of patents, which indicates that the unit has strong industrial collaboration and that they make themselves very useful for the industry in the region. The industrial collaboration has, however, in many cases limited the possibilities for publishing results. Although the research in design methodology is carried out with limited resources it is of good quality, and shows a lot of potential.

Research environment

The administrative load has been very high during the last few years because of structural changes at the department and in education. The unit has also a high educational load, leaving little time for basic research. The unit reported only two PhD theses during the period of assessment, and these took 10–11 years to complete. The facilities to conduct research in the area of application are limited. In most cases, there is no equipment or machinery to do research work on paper machines or any other large machines or systems. The only possibility is to do the research work using partner facilities and equipment.

Research networking and interaction

The unit has a very extensive industrial network and has recently managed to become part of an EU project, which will boost international exposure. The unit's academic networking is more limited, however.

Recommendations

The unit is clearly under critical mass, and a merger with another group or other groups should be considered. The unit's projects are often more product development than research. It must be recognised, however, that in the area of engineering design, the development of skills is, besides research, also important in order to be able to educate good future engineers. Nevertheless, in this case, more attention to basic research is needed. The unit should consider bringing more emphasis to modern areas such as systems engineering, design automation and product modelling. Within the group there are already some efforts in these areas and these should be encouraged.

4.29 UO Materials Engineering Laboratory

Overview

The unit is placed in the Department of Mechanical Engineering and in the Centre for Advanced Steels Research (CASR). CASR is part of the Oulu city innovation strategy, established in 2006, and consists of six teams, of which three work within process engineering (incl. UO Laboratory of Process Metallurgy), one within electrical engineering and the remaining two within the unit. Since 2000, the unit has had 2–3 professors and 1–2 senior researchers. One chair has been vacant since 2004.

The age profile of staff is mixed. Graduates are employed to work on industrial projects or as assistants, often with a heavy teaching load. These graduates have not taken postgraduate courses and have conducted very little research. The unit has also had overseas graduates doing research towards completing the PhD degree on a topic of their own and working on other projects.

Total funding in 2000–2007 stood at about 1.5 million euros per year. The funding, as a percentage of total funds, has come from the budget (42%), industry (33%), Tekes (8%), the EU (8%), private foundations (4%), the Academy of Finland (3%) and from various other sources (2%). Core funding did not cover all salaries. Technical staff are mostly paid by the projects. Increased EU funding has just managed to compensate the erratic funding from Tekes and the Academy of Finland. Overall, funding per year did not increase over the period of assessment. Securing funding to keep staff is a big challenge.

Research profile

The unit has two research groups (Physical Metallurgy and Mechanical Metallurgy), each led by a professor. Its strategy was defined in consultation with the Finnish steel industry and is targeted at research and technology transfer to meet the needs of Finnish companies, to assist their R&D and to train engineers needed by them.

Currently, the research activities of the unit are directed solely towards the manufacturing of steels and their properties and service applications. The emphasis is on (i) modern advanced high-strength steel types such as dual-phase and triple-phase (DP, TRIP) steels, high-Mn twinning-induced plasticity (TWIP) steels, low-carbon bainitic steels and martensitic direct-quenched and tempered (DQ-T) steels; (ii) modelling of scale and thermomechanical behaviour of rolling processes, and the profile and shape of rolled products, using extended FEM, PhaseField, LevelSet and inverse modelling techniques as well as self organising maps (SOM); and (iii) experimental investigation of the heat transfer effectiveness of heating and cooling processes.

The unit is strategically placed to address breakthrough materials in MeKo-SHOK (Section 1.2), and research is planned in this area. The unit has very strong links to Outokumpu and Ruukki.

Research quality

The unit is a steel metallurgy group with unique strengths. It has very strong expertise that took almost 20 years to build up. The unit conducts quality research and a significant part of it is original. The impact is noteworthy when considering the relevance of its work to the needs of industry. Work is underway in the unit to improve the academic impact of its research. The latter will be assisted by future developments in CASR and planned collaboration with overseas Centres of Excellence.

The publication record is significantly better compared to that of other units, and is improving steadily. The number of PhD students is better compared to other units but low compared to overseas materials research groups. The appointment of Professor DeArdo in CASR as a Finland Distinguished Professor via the FiDiPro programme, funded by the Academy of Finland and Tekes, is expected to have a positive impact on the unit's research and productivity.

Research environment

There is a strong team spirit. Much time and effort is spent on providing services to industry, raising much needed funds to keep the laboratories running and paying salaries of staff; all these have an adverse effect on academic research, in particular basic and fundamental research. Given the pressures on staff time for funding their research, the unit has mechanisms in place to address longer-term innovation.

Although the unit recently acquired a new FEGSEM (Field Emission Gun Scanning Electron Microscope) and has access to microstructural characterisation facilities both at home and overseas, the quality and quantity of its research are threatened by ageing equipment. Research also suffers from low staff numbers, staffing policies of the university, administrative and educational loads of staff, national funding streams for materials research and short-term priorities.

The age profile of senior staff is also of concern. Opportunities for career progression for able and well-qualified staff are limited. MeKo-SHOK (Section 1.2) and the graduate school provide opportunities for research, but even these (i.e. MeKo-SHOK and the graduate school) are driven by industry needs.

Research networking and interaction

There is outstanding international networking and collaboration across all continents. National collaboration and networking with academia and industry is impressive. Within Finland, the industrial impact is very significant.

Recommendations

The unit is very well placed to explore opportunities for multidisciplinary research and improve the balance between academic research and services to industry. There is a pool of high-quality expertise that would allow the unit to expand its portfolio of fundamental research and to gradually diversify its research and start addressing other materials. The unit must re-define its strategy, give priority to academic issues and continue to plan for long-term research with strong emphasis on innovation.

4.30 UO Mechatronics and Machine Diagnostics Laboratory

Overview

The unit has two professors, one postdoctoral researcher and four PhD students belonging to the staff. The total number of PhD students is about 10. The unit has a profile towards machine condition monitoring and diagnostics and mechatronics. With this profile, the unit is rather unique in Finland. The total funding in 2000–2007 was about 0.6 million euros per year. The unit has a balance in their funding between core funding (69%) and external funding (31%). The external funding comes from the Academy of Finland, Tekes and industry.

Research profile

The research towards machine condition monitoring and diagnostics concentrates on slowly rotating machines, with applications found in the pulp and steel industry as well as in water and wind turbines. Research into mechatronics concentrates on virtual design of mechatronic machines and devices, robotics in surgery, model-based control of intelligent materials and structures, and on active and semi-active vibration control.

Research quality

The unit has a balanced approach to theoretical and experimental research. Journal publications in this unit are quite strong. However, one concern is that the journals are not really in the mechatronics area. The unit has a strong profile in machine diagnostics, which could produce more publications.

Research environment

The research environment seems very positive. The unit is a very good example of a unit that places large emphasis on PhD studies. The unit is one of very few in Finland that have a working PhD programme, with a consistent time-to-degree of around four years. They also have fewer problems to recruit new PhD students. In many ways this unit can serve as a model for combining applied research with PhD studies that are finished on time. The unit also manages to have industrial cooperation with little negative effects on limitations on publications; instead there is strong synergy.

Research networking and interaction

The unit has an extensive and active research network, both internationally and nationally. Scientific collaboration has been carried both within the university, with other units, as well as with the technical universities of Magdeburg and Clausthal in Germany, mainly in the area of machine diagnostics. This is a testament of the unit's international standing. The unit has also collaborated with different universities of technology and with VTT in Finland within various Tekes projects.

Recommendations

The unit has a good number of journal publications, but a recommendation is to target standard journals in the area. In this way, more critical peer review could be obtained.

The unit is one of very few in Finland that have a working PhD programme, with PhD studies that are finished on time. One recommendation is, however, to ensure that at least some research in the group is more of a basic nature.

4.31 UO Production Technology Laboratory

Overview

The Production Technology Laboratory, placed within the Faculty of Technology at the University of Oulu, has two professors, three other academic staff and four PhD students, and in addition two lab technicians. The unit's total funding amounts to about 0.5 million euros per year, distributed as follows: university budget 85 per cent, Tekes 6 per cent, industry 3 per cent and private foundations 6 per cent. The unit has no funding from the Academy of Finland and there has only been very little EU funding (€11,000 in 2002). The number of staff has been fairly stable over the evaluation period and total funding has decreased only slightly.

Research profile

The general objective is to research agile manufacturing to meet the needs of a rapidly changing industrial environment.

The unit's current research profile contains the following topics: (i) flexible manufacturing automation for small batches, one-of-a-kind devices and prototypes, in particular flexible manufacturing systems (FMS), automated process planning, tool path simulation, direct tool path code generation from CAD models for STEP-NC, the current advanced numerical control standard, 3D laser milling, micromachining and precision mechanics/space instruments; and (ii) ultra high-strength steel (UHSS) sheet metal manufacturing processes and component design, in particular cutting, punching, laser assisted bending, welding, process simulation, machinability and design of HSS and UHSS structures.

New strategic topics include feature-based process planning and UHSS steel processing (from currently 4 mm to approx. 20 mm thickness).

Research quality

The unit has relatively low publication activity, mostly conference papers and only one journal paper, in 2007. Currently, the unit has four PhD students, of which three work in industry. The unit reported only one PhD completed (in 2004, with time-to-degree 7 years) during the evaluation period, but the situation is improving. Three PhD completions are planned for 2008 and one for 2009.

The unit has unique competence and strength in design, manufacturing and assembly of complex one-of-a-kind space mechanics devices. The unit is, and has been, carrying out a number of very qualified space projects, for NASA, ESA, KTH-Alfvén Laboratory Centre for Space and Fusion Plasma Physics, and the Swedish Space Corporation. The panel was impressed by a number of complex instruments for measurements in space that were demonstrated. The unit has also developed methods for micromachining of components and moulds in hard materials (e.g. tungsten carbide), and manufacturing processes for UHSS (Ultra High-Strength Steels).

Research environment

The unit has versatile facilities with good and reasonably modern equipment, for example machine tools and 3D laser (four mechanical and three optical axes), a coordinate measuring machine and a welding robot. There is also laser sintering equipment available (currently not used due to lack of staff and time). The unit has very limited personnel resources and difficulties to recruit PhD students due to competition from industry. The salary ratio industry-university is about 1.5. Another problem is the rapid staff turnover. The UO location in Northern Finland was considered by the staff to be a bit "off", in terms of international cooperation.

The unit has very modest funding and is primarily relying on university core funding, with only some smaller additional funding from Tekes and industry. The unit has no Academy of Finland or EU funding. One reason for the low publication activity is a lack of time due to a high teaching load (25 MSc theses per year).

Production technology is a very popular subject among students. Teaching therefore takes up most of the time and resources of the unit. However, researchers allocated to a project budget usually do not have to participate in teaching. Another explanation for the low publication activity is the confidentiality problem with industry-related projects.

Research networking and interaction

The unit's research is of an interdisciplinary character, with interdisciplinary research cooperation. National research partners include the University of Lapland, TUT, HUT and VTT, and some collaboration is also carried out with the UO Materials Engineering Laboratory. The unit is, for example, cooperating with TKK, TUT and LUT in the manufacturing of wind turbine gears.

The list of domestic industrial partners is comprehensive. There are a number of local industrial partners, with Oulu Precision Mechanics Manufacturing Centre (PMC) mentioned as one important collaborator. A significant part of the unit's research is based on services to industry, of mutual benefit for companies and the university unit. An example of these activities is the testing of manufacturing properties of new high-strength steel grades for the steel industry.

The unit has good international research cooperation, particularly within the field of space equipment development with a number of partners: University of California-Berkeley, NASA, Space Sciences Laboratory (USA), ESA and KTH-Alfvén Laboratory Centre for Space and Fusion Plasma Physics. Collaborators within laser processing include Vienna University of Technology and Luleå Technical University. TU Erlangen-Nurenberg is a research collaborator within the forming of sheet metal.

Recommendations

The unit has unique competence in prototype and space equipment design and manufacturing that is not being fully utilised due to a lack of resources (funding and staff). In terms of design and manufacturing of complex one-of-a-kind space mechanics devices, the unit was in the early 1980s the foremost unit in the world, but now has difficulties in keeping this position due to limited resources. Within laser machining and other laser assisted processes, there are currently many research groups internationally.

Increased university core funding related to laboratory-intensive teaching and based on the number of graduated PhDs is recommended. The panel also recommends that the unit seek Academy of Finland funding for more stable, long-term funding, as well as PhD graduate school positions. There is an obvious risk that this unique and qualified unit cannot survive due to the lack of resources. A general comment – not only regarding this unit – is that the university salary system is limiting the possibilities for recruiting PhD students.

A. Statistics of mechanical engineering research in Finland 2000–2007

A.1 Introduction

The statistical and other results in this appendix are based on data from the self-assessment forms that were sent to the selected 31 units at the end of 2007 (Appendix D). The form requested basic quantitative data from the evaluation period: personnel resources, funding, research output and education. The units were also asked to describe their research activities and strategies, together with national and international collaboration, and provide a detailed self-assessment with a SWOT analysis.

Of the 31 units, 30 are from universities. On the other hand, the Knowledge Cluster of VTT Technical Research Centre of Finland (VTT/IndSys) is a section of a large research institute and is in many respects not directly comparable to the university units. It was also able to give the self-assessment only for the period 2002–2007. VTT/IndSys is much larger than any of the other units and comprises 28 per cent of the personnel and 34 per cent of the total funding for all units. For these reasons, VTT/IndSys is often treated separately in the statistics.

A.2 The research units and their host organisations

The units

The units in this evaluation are listed in Table 1. The TKK unit names refer to the old organisation, which was in operation until the end of 2007. The relationships of TKK units to the present organisation are described below. All other units have their present names. The abbreviations of the units are coined for the presentation purposes of this report and are not official abbreviations.

Helsinki University of Technology (TKK)

TKK is the largest technical university in Finland. The roots of TKK go back to the 1800s and it gained its present status in 1908. It has 15,000 students, a staff of 3,300 and funding to the tune of 230 million euros. Until the end of 2007, TKK had twelve departments divided into more than a hundred laboratories. The names of the TKK units follow this old organisation.

TKK's organisation has been restructured so that as from 2008 there are four faculties instead of the previous departments. On the other hand, the subunits of the faculties are now called departments and are 25 in total. In some cases, these correspond roughly to the old departments, in other cases to new groupings of former laboratories. Each department has a number of research groups or other subunits. Presently, the research groups more or less correspond to the former

Table 1. The units and their abbreviations.

1	TKK/AutomTech	Department of Automation and Systems Technology, Automation Technology Laboratory
2	TKK/CorrMater	Department of Materials Science and Engineering, Laboratory of Corrosion and Materials Chemistry
3	TKK/MaterSci	Department of Materials Science and Engineering, Laboratory of Materials Science
4	TKK/Metallurgy	Department of Materials Science and Engineering, Laboratory of Metallurgy
5	TKK/ProcHeat	Department of Materials Science and Engineering, Laboratory of Processing and Heat Treatment of Materials
6	TKK/MaterProc	Department of Materials Science and Engineering, Laboratory of Materials Processing and Powder Metallurgy
7	TKK/CombEng	Department of Mechanical Engineering, Internal Combustion Engine Laboratory
8	TKK/Aerodyn	Department of Mechanical Engineering, Laboratory of Aerodynamics
9	TKK/Automotive	Department of Mechanical Engineering, Laboratory of Automotive Engineering
10	TKK/EngMater	Department of Mechanical Engineering, Laboratory of Engineering Materials
11	TKK/Foundry	Department of Mechanical Engineering, Laboratory of Foundry Engineering
12	TKK/Lightweight	Department of Mechanical Engineering, Laboratory of Lightweight Structures
13	TKK/MachDes	Department of Mechanical Engineering, Laboratory of Machine Design
14	TKK/MechMater	Department of Mechanical Engineering, Laboratory for Mechanics of Materials
15	TKK/ProdEng	Department of Mechanical Engineering, Laboratory of Production Engineering
16	TKK/Ship	Department of Mechanical Engineering, Ship Laboratory
17	LUT/MechatrFatig	Department of Mechanical Engineering, Section of Engineering Design, Laboratory of Mechatronics and Virtual Engineering, Laboratory of Fatigue and Strength (VIDIMS: Centre of Excellence in Research in Virtual Design of Intelligent Machine Structures and Systems)
18	LUT/ProdEng	Department of Mechanical Engineering, Section of Production Engineering
19	LUT/WoodTech	Department of Mechanical Engineering, Section of Wood Technology, Laboratory of Wood Technology
20	TUT/HydrAutom	Department of Intelligent Hydraulics and Automation
21	TUT/MechDes	Department of Mechanics and Design
22	TUT/MaterSci	Department of Materials Science
23	TUT/ProdEng	Department of Production Engineering
24	TUT/SafetyEng	Department of Industrial Management, Center for Safety Management and Engineering
25	VTT/IndSys	VTT Technical Research Centre of Finland, Industrial Systems Knowledge Cluster
26	UO/EngMech	Department of Mechanical Engineering, Engineering Mechanics Laboratory
27	UO/Metallurgy	Department of Process and Environmental Engineering, Laboratory of Process Metallurgy
28	UO/MachDes	Department of Mechanical Engineering, Machine Design Laboratory
29	UO/MaterEng	Department of Mechanical Engineering, Materials Engineering Laboratory
30	UO/Mechatr	Department of Mechanical Engineering, Mechatronics and Machine Diagnostics Laboratory
31	UO/ProdTech	Department of Mechanical Engineering, Production Technology Laboratory

laboratories, however, this term is not used any more. Apart from this, the names of the research groups have changed somewhat, but not past identifiability. The units in Table 1 were placed within the new organisation roughly as follows:

- 1 TKK/AutomTech was included into the Department of Automation and Systems Technology in the Faculty of Electronics, Communications and Automation
- 2 TKK/CorrMater, 3 TKK/MaterSci, 4 TKK/Metallurgy, 5 TKK/ProcHeat and 6 TKK/MaterProc were included into the Department of Materials Science and Engineering in the Faculty of Chemistry and Materials Sciences
- 9 TKK/Automotive, 10 TKK/EngMater, 11 TKK/Foundry, 13 TKK/MachDes and 15 TKK/ProdEng were included into the Department of Engineering Design and Production in the Faculty of Engineering and Architecture
- 8 TKK/Aerodyn, 12 TKK/Lightweight, 14 TKK/MechMater and 16 TKK/Ship were included into the Department of Applied Mechanics in the Faculty of Engineering and Architecture
- 7 TKK/CombEng was included into the Department of Energy Technology in the Faculty of Engineering and Architecture.

Lappeenranta University of Technology (LUT)

LUT was founded in 1969 and presently has 5,500 students, a staff of 900 and funding to the tune of 61 million euros. As from 2007, the university has had three faculties. The Faculty of Technology has four departments, one of which is the Department of Mechanical Engineering. This department is further divided into three sections. The Section of Engineering Design comprises LUT/MechatrFatig with some small supportive units. The Section of Wood Technology comprises LUT/WoodTech with some small regional units outside Lappeenranta. The third section is LUT/ProdEng.

Tampere University of Technology (TUT)

TUT has 12,600 students, a staff of 1,900 and funding to the tune of 134 million euros. It was founded as a branch of HUT in 1965 and gained full university status in 1972. Until the end of 2007, the university consisted of ten departments and 35 institutes. As from 2008, there are instead five faculties and 22 departments. Here, the new departments correspond in part to certain former institutes, while in other cases institutes have been combined or their profiles otherwise changed.

The Faculty of Automation, Mechanical and Materials Engineering combines three previous departments that corresponded to the three fields. The Faculty now has five departments. Four are included in the mechanical engineering evaluation, the one left out being the Department of Automation Science and Engineering. TUT/HydrAutom, TUT/MaterSci and TUT/ProdEng more or less correspond to former institutes. On the other hand, TUT/MechDes combines two former institutes (Institute of Machine Design, Institute of Applied Mechanics and Optimisation) and adds one energy engineering chair.

The Faculty of Business and Technology Management has two departments. One is the Department of Industrial Management to which TUT/SafetyEng belongs as relatively independent subunit. It corresponds to the former Institute of Occupational Safety Engineering.

VTT Technical Research Centre of Finland

VTT Technical Research Centre of Finland is the largest research institute in northern Europe and has facilities in ten Finnish cities. It produces technological research, development and testing services to the private and public sector. From the 1980s, VTT's external funding has exceeded its core funding. The 2006 turnover was 217 million euros and the personnel almost 2,780. After its founding in 1942 VTT has undergone several organisational changes that have joined smaller units together into larger entities. In 1994, the 39 laboratories and four divisions were replaced by nine independently accountable research institutes, two of which were VTT Automation and VTT Manufacturing. These were further combined into VTT Industrial Systems in 2002, when the number of institutes was further reduced to six. The organisation was changed in 2006 to a matrix type in which VTT/IndSys is one of seven Knowledge Clusters. The accounting principles were also changed thereby.

University of Oulu (UO)

UO was founded in 1958 and is the third largest university in Finland with its 16,000 students, a staff of 3,100 and a total funding of 207 million euros. The Faculty of Technology is one of six faculties and its share is 4,000 students and a staff of 700. The Faculty is further divided into five departments. The Laboratory of Process Metallurgy is in the Department of Process and Environmental Engineering, while the other five units constitute the Department of Mechanical Engineering.

A.3 Profile of mechanical engineering research

The self-assessment form asked for the percentage that mechanical engineering research constitutes of the unit's research; this percentage is given in the first column of Table 2. The mechanical engineering part was then to be divided further into subfields shown in Table 2; the subfield percentages add to 100 per cent. The mechanical engineering percentage was in some cases very small. Certain units were involved only marginally in mechanical engineering (e.g. wood technology, safety engineering), while in other cases this is due to interpretation (e.g. dividing line between energy engineering and mechanical engineering). For 14 of the 31 units this percentage is 100 per cent. The estimated percentage of mechanical engineering research of total funding is 85 per cent for all units and 77 per cent for universities only.

In its assessment, the evaluation panel decided to define the subfields so that they better correspond to the actual research conducted within mechanical engineering. The subfields in this appendix are, thus, somewhat different from those in Section 3, Evaluation of Subfields:

- Subsections 3.1 'Automation, control engineering and mechatronics', 3.2 'Engineering design', 3.3 'Engineering materials' and 3.7 'Vehicle engineering' correspond to the Appendix A subfields 'Machine automation', 'Machine design', 'Material technology' and 'Vehicle technology' respectively.
- Subsection 3.4 'Production and manufacturing' combines 'Manufacturing and tooling' and 'Production engineering'.
- Subsections 3.5 'Applied mechanics' and 3.6 'Thermodynamics' refer to fields of important basic research not defined in the self-assessment form. Applied mechanics research can in part be found in the 'Other, specification' column in Table 2.

The subfield percentages reported by the units have been edited somewhat so that the criteria are more in line. Most importantly, if mechatronics has been included in the category 'Other', it has been moved to the 'Machine automation' category. This agrees also with the subsection 3.1 heading.

It was instructed in the self-assessment form that if mechanical engineering does not comprise 100 per cent of research, all remaining questions concern only the mechanical engineering part of the research. However, as concerns detailed quantitative tables of year-to-year resources and results, it has not been possible for the units to separate the mechanical engineering part from integral research projects. Thus, in this appendix, detailed unit figures refer to the whole unit and not to the mechanical engineering part of the research. On the other hand, when statistics for mechanical engineering research in Finland or at universities is considered, these are estimated using the mechanical engineering percentages in Table 2. It is clearly stated when this is the case.

The mechanical engineering percentage of VTT/IndSys is 60 per cent. However, VTT has a considerable share of mechanical engineering research also outside VTT/IndSys. The volume of this research is estimated by VTT to be about the same as the remaining 40 per cent of VTT/IndSys. Therefore, when general statistics of Finnish mechanical engineering are considered, the percentage 100 per cent instead of 60 per cent is used for VTT.

It is also to be noted, that the reported resources refer to all activities of the units. The units were not asked to divide the resources between actual research, contractual research services, education etc. Especially the share of basic education of the funding and personnel resources varies considerably.

The percentages of subfields for all units taken together are shown in Figure 1. The percentages refer to the funding allocated to the subfields and are estimated using Table 2 data and the funding data in Table 7.

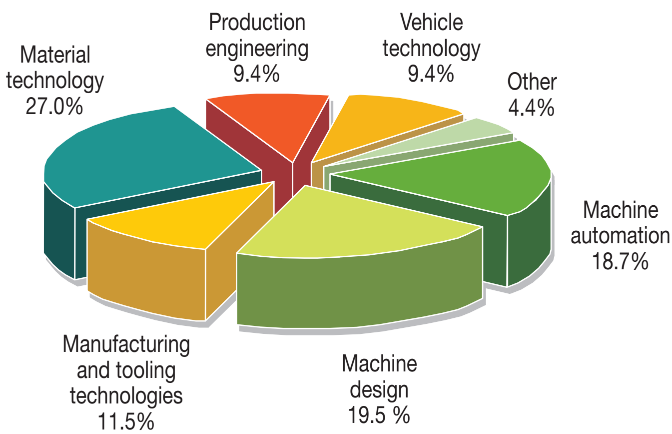


Figure 1. Subfields of Finnish mechanical engineering research.

Table 2. Research profile of the evaluated units; percentage of mechanical engineering research of all research; and percentages of mechanical engineering subfields of all mechanical engineering research.

		%	Percentage of subfield of mech. eng. research of unit							
		Mech. eng. research of unit's research	Machine automation	Machine design	Manufacturing and tooling	Material technology	Production engineering	Vehicle technology	Other	Other, specification
1	TKK/AutomTech	80	60	10				30		
2	TKK/CorrMater	30			10	50			40	Corrosion prevention
3	TKK/MaterSci	75				100				
4	TKK/Metallurgy	80				100				
5	TKK/ProcHeat	95	15	5	30	25	20	5		
6	TKK/MaterProc	80		3	3	91	3			
7	TKK/CombEng	10		100						
8	TKK/Aerodyn	100						50	50	Civil and process engineering
9	TKK/Automotive	85	30	10	20			40		
10	TKK/EngMater	100		0	40	60				
11	TKK/Foundry	80		30	20	30	10		10	Environmental issues
12	TKK/Lightweight	100		25	25	25		25		
13	TKK/MachDes	100	23	52	9	16				
14	TKK/MechMater	100							100	Solid mechanics, material and numerical modelling
15	TKK/ProdEng	100	5	5	20	5	60		5	Computer science
16	TKK/Ship	100		10				70	20	Ice mechanics
17	LUT/MechatrFatig	100	20	80						
18	LUT/ProdEng	100	10	15	10	20	45			
19	LUT/WoodTech	5			20	50	30			
20	TUT/HydrAutom	100	100							
21	TUT/MechDes	100	20	40	5	5	5	5	20	Solid mechanics
22	TUT/MaterSci	25			20	80				
23	TUT/ProdEng	40	30	20	20		30			
24	TUT/SafetyEng	20	25	25			50			
25	VTT/IndSys	60	13	23	15	23	13	13		
26	UO/EngMech	100		1		17			82	Engineering mechanics and structural engineering
27	UO/Metallurgy	60				90	10			
28	UO/MachDes	95		80				20		
29	UO/MaterEng	96				97	3			
30	UO/Mechatr	100	100							
31	UO/ProdTech	100	5		80	5	10			

A.4 Personnel resources

The units were asked to provide their person-month statistics for different personnel categories and for each year of the evaluation period. The data refers to all activities of the units as the earmarking of the person-months for mechanical engineering versus other research has not been possible. The detailed data is in Tables 10–14 while Table 4 shows the units' average manpower during the evaluation period in terms of FTEs (full time equivalents). Total research personnel FTEs for the units are in Figure 2. A median unit would have 17 researchers of which four would be seniors.

The variation appears large. However, most small units are former TKK laboratories that are presently combined into larger departments. The TKK units included in the Department of Materials Science and Engineering add to 73 research FTEs, the units included in the Department of Engineering Design and Production to 97 FTEs, and those included in the Department of Applied Mechanics to 48 FTEs. The units from LUT and UO Mechanical Engineering Departments add to 70 and 51 FTEs respectively, and the four TUT departments have 63, 45, 82 and 45 FTEs. Thus, on the department level, the variation is not as large. They have about 50–100 FTEs, while VTT/IndSys has about 170 FTEs.

The overall FTEs for research staff and all personnel is 790 and 1,030 respectively for all units and 615 and 775 for universities only. The research staff percentages for universities are shown in Figure 3 and the unit FTEs for their principal personnel categories in Figure 4. The senior categories comprise 26 per cent of research staff while almost 50 per cent of all research FTEs are postgraduates.

Average FTE data for VTT/IndSys are shown in Figure 5. VTT/IndSys counts also researchers with MSc degrees as seniors and does not have a postgraduate category. Neither does the profile of VTT research professors correspond to university chairs. However, the VTT annual report states that 23 per cent of all research staff are doctors and licentiates, which is comparable to the university figures.

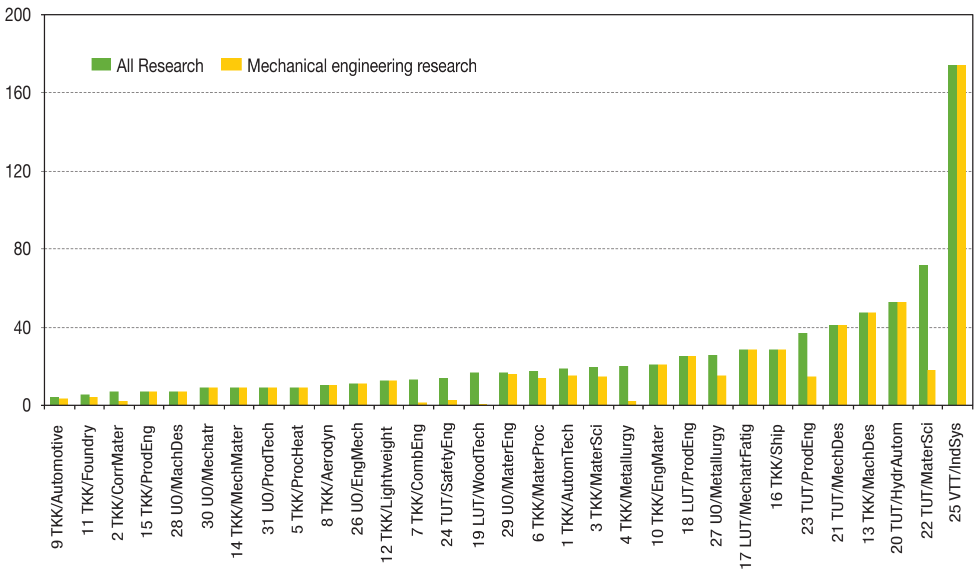


Figure 2. Average FTEs of research staff for all research; estimate of mechanical engineering part of the research.

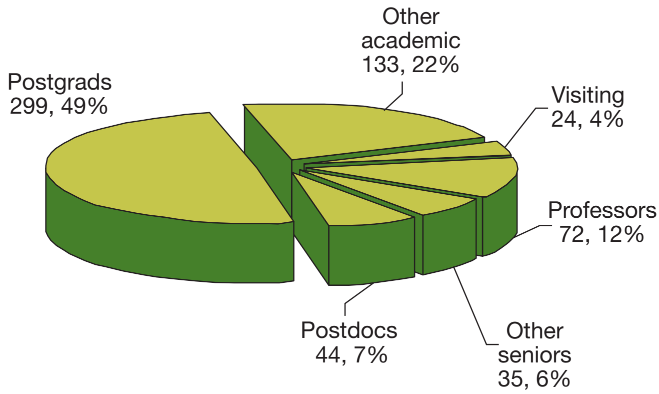
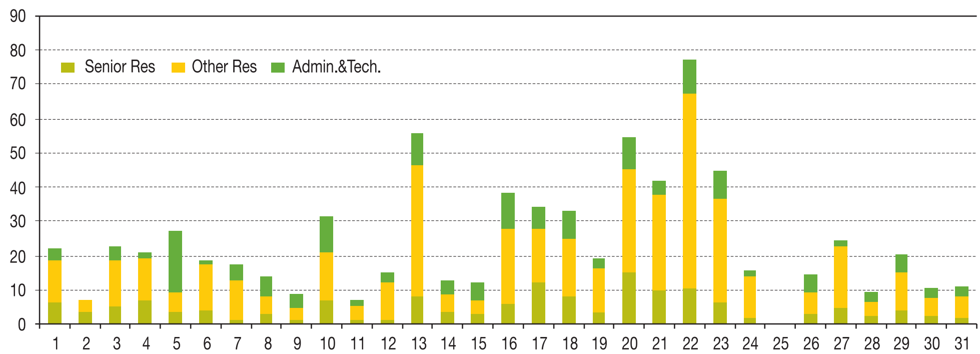


Figure 3. University research staff FTEs (evaluation period averages).



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 4. FTEs for senior researchers (professors, postdoctoral researchers and other seniors), other research staff and administrative and technical staff. VTT/IndSys is not shown.

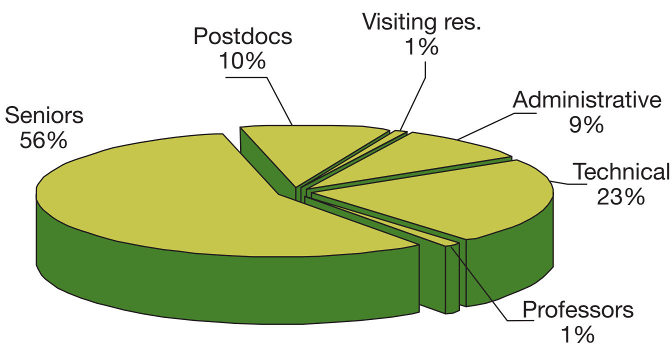


Figure 5. VTT/IndSys average FTEs.

Table 3. Development of personnel resources for universities and VTT/IndSys.

	2000	2001	2002	2003	2004	2005	2006	2007	Increase % 2000–2007
Professors	68	70	70	70	74	77	75	76	12
Seniors	31	28	32	31	34	35	37	33	8
Postdocs	34	32	37	40	41	46	45	56	65
Prof., sen., postdocs	132	130	139	140	149	158	157	165	25
Postgraduates	270	260	267	278	315	304	316	312	16
Other acad. staff	130	135	138	136	129	130	125	139	7
Visiting	20	25	24	27	22	21	24	23	13
Total university research staff	**552**	**550**	**568**	**582**	**614**	**613**	**622**	**639**	16
VTT/IndSys total research staff			169	160	158	166	200	193	

At the universities there is a 16 per cent increase of research staff during the evaluation period, see Table 3. This is mostly during 2001–2004, after which the trend slows down. The increase is strongest for postdoctoral researchers and appears to proceed in clear steps. The missing years and the sudden increase for VTT/IndSys are due to organisational changes.

If it is assumed that all university researchers in the senior categories (professors, postdoctoral researchers and other senior researchers) have a PhD degree, PhDs comprise 25 per cent and professors 12 per cent of all research staff, the unit ranges being 9–38 per cent and 4–34 per cent respectively. Professors comprise 48 per cent of all PhDs, that is, almost every other is a professor. The range is 14–100 per cent, the latter being the case in four units. The same percentages for the universities are shown in Figure 6.

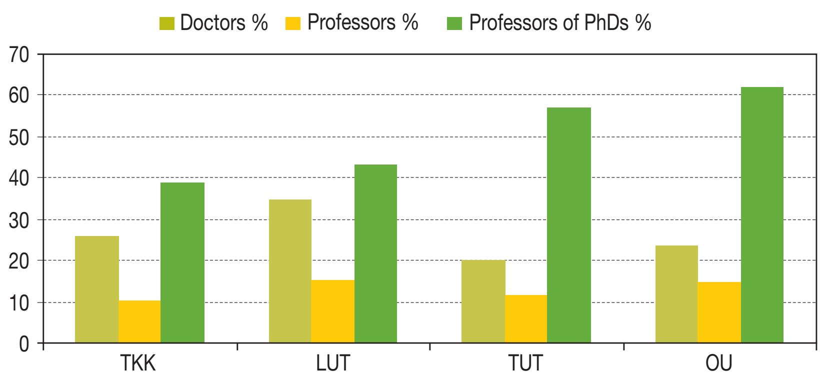


Figure 6. Percentage of PhDs and professors of all research staff and percentage of professors of PhDs.

Table 4. Average FTEs of research staff.

		Professors	Other senior researchers	Postdoctoral researchers	Total senior researchers	Postgraduate students	Other academic staff	Visiting researchers and res. students	Total research staff	Administrative and technical personnel	Total personnel
1	TKK/AutomTech	1.5	2.2	3.0	**6.7**	10.6	1.0	0.8	**19.1**	**4.1**	**23.2**
2	TKK/CorrMater	1.0	2.3	0.0	**3.3**	4.0	0.0	0.0	**6.8**	**0.0**	**6.8**
3	TKK/MaterSci	1.7	2.5	1.2	**5.4**	6.8	6.3	0.9	**19.4**	**4.2**	**23.6**
4	TKK/Metallurgy	1.3	3.0	3.0	**7.3**	12.0	0.0	0.8	**20.0**	**1.8**	**21.8**
5	TKK/ProcHeat	1.3	1.9	0.2	**3.3**	6.0	0.0	0.1	**9.4**	**18.0**	**27.4**
6	TKK/MaterProc	1.0	0.9	2.2	**4.1**	9.2	3.9	0.3	**17.6**	**1.4**	**18.9**
7	TKK/CombEng	1.0	0.2	0.1	**1.3**	1.4	10.4	0.1	**13.0**	**4.6**	**17.7**
8	TKK/Aerodyn	1.0	1.1	0.6	**2.7**	2.3	3.3	2.4	**10.7**	**5.5**	**16.1**
9	TKK/Automotive	1.0	0.0	0.0	**1.0**	1.5	2.4	0.4	**4.3**	**3.6**	**7.9**
10	TKK/EngMater	1.0	3.2	3.0	**7.1**	12.7	1.0	3.2	**20.6**	**10.5**	**31.1**
11	TKK/Foundry	1.0	0.0	0.1	**1.1**	1.2	2.8	0.1	**5.3**	**2.0**	**7.3**
12	TKK/Lightweight	1.0	0.0	0.0	**1.0**	0.3	10.7	0.4	**12.4**	**3.1**	**15.5**
13	TKK/MachDes	4.0	2.5	1.9	**8.3**	18.2	20.2	0.5	**47.2**	**9.1**	**56.3**
14	TKK/MechMater	1.7	1.4	0.7	**3.8**	3.3	1.6	0.2	**8.9**	**4.0**	**12.9**
15	TKK/ProdEng	2.0	1.0	0.0	**3.0**	2.0	2.0	0.0	**7.0**	**5.0**	**12.0**
16	TKK/Ship	3.8	0.4	1.4	**5.6**	9.4	12.8	0.9	**28.6**	**10.4**	**39.0**
17	LUT/MechatrFatig	4.0	0.0	8.3	**12.3**	15.8	0.0	0.2	**28.3**	**6.0**	**34.3**
18	LUT/ProdEng	4.1	1.4	2.9	**8.3**	12.6	4.0	0.1	**25.1**	**8.0**	**33.1**
19	LUT/WoodTech	2.5	0.8	0.4	**3.7**	10.8	2.0	0.0	**16.4**	**3.0**	**19.4**
20	TUT/HydrAutom	5.1	3.5	6.6	**15.1**	29.9	0.0	4.7	**53.1**	**9.6**	**62.7**
21	TUT/MechDes	6.4	0.9	2.6	**9.9**	17.7	10.4	3.0	**40.9**	**4.0**	**44.9**
22	TUT/MaterSci	6.8	2.0	1.8	**10.5**	50.6	6.3	4.3	**71.6**	**10.1**	**81.8**
23	TUT/ProdEng	5.1	0.0	1.4	**6.5**	22.9	7.4	0.1	**36.9**	**7.8**	**44.6**
24	TUT/SafetyEng	1.5	0.0	0.0	**1.5**	11.9	0.4	0.4	**14.1**	**1.8**	**15.9**
25	VTT/IndSys	2.8	144	25.7	**172**	0.0	0.0	2.2	**174**	**80.8**	**255**
26	UO/EngMech	1.3	0.9	0.9	**3.1**	1.2	5.0	0.2	**11.3**	**5.4**	**16.7**
27	UO/Metallurgy	1.0	1.6	1.7	**4.4**	7.2	11.0	0.0	**25.7**	**2.1**	**27.8**
28	UO/MachDes	2.5	0.1	0.0	**2.5**	3.2	0.6	0.0	**7.1**	**3.3**	**10.4**
29	UO/MaterEng	2.5	1.6	0.1	**4.2**	6.4	4.2	0.1	**17.0**	**5.2**	**22.3**
30	UO/Mechatr	2.2	0.0	0.2	**2.4**	5.2	0.0	0.1	**8.8**	**2.8**	**11.6**
31	UO/ProdTech	2.0	0.0	0.0	**2.0**	2.5	3.4	0.0	**9.0**	**3.4**	**12.4**
Total, excl. VTT		**72**	**35**	**44**	**151**	**299**	**133**	**24**	**615**	**160**	**775**
Total, incl. VTT		**75**	**179**	**70**	**323**	**299**	**133**	**26**	**790**	**240**	**1,030**

A.5 Funding resources

The units were asked to provide their funding statistics for different core and external funding categories and for each year of the evaluation period. Table 7 gives the average funding per year for each unit, while the detailed annual funding data is in Tables 15–22, which, however, do not include the foundations category due to its negligible volume.

The funding for all units taken together is in Table 5, which also includes the funding percentages for universities and VTT/IndSys. The total funding is 74 million euros per year of which universities take up 49 million euros, or on average 1.6 million euros per unit, and VTT/IndSys 25 million euros. The funding targeted to mechanical engineering only is estimated to 62 million euros for all units and 37 million euros for universities. The core funding covers 44 per cent for universities and 30 per cent for VTT/IndSys. However, it is seen that the funding profiles of the universities vary significantly. The bulk of external funding is from industry and Tekes, 38 per cent of all funding for universities and 46 per cent for VTT/IndSys. The money from the Academy of Finland covers 4 per cent of the funding for universities and EU funding is 5 per cent overall.

The total external and core funding for university units is shown in Figure 8. Core funding ranges from 22 to 82 per cent. The two next largest sources of funding are industry and Tekes with approximately equal shares. The Tekes range is from 5 to 37 per cent and the industry range from 3 to 42 per cent.

Table 5. Average funding per year.

	All units		Universities		TKK %	LUT %	TUT %	VTT %	UO %
	k€	%	k€	%					
Budget	28,234	39	20,812	42	46	25	41	30	51
Other core	1,056	1	1,056	2	0	2	5	0	0
Academy	2,029	3	2,005	4	4	3	5	0	3
Tekes	13,446	18	10,330	21	21	28	22	13	18
Other public	6,716	9	3,387	7	5	4	11	13	9
Industry	16,327	23	8,198	17	17	26	13	33	22
Foundations	337	<1	337	1	0	0	0	0	0
EU	4,025	5	2,433	5	6	9	3	6	5
Other foreign	1,409	2	265	<1	1	2	0	5	2
Total k€	**73,580**		**48,823**		**21,147**	**4,682**	**17,899**	**24,757**	**5,096**

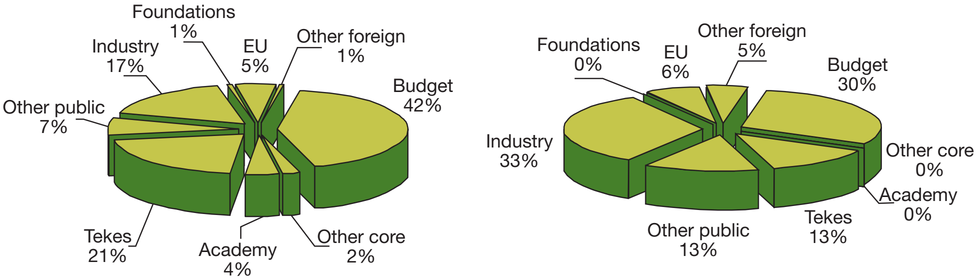
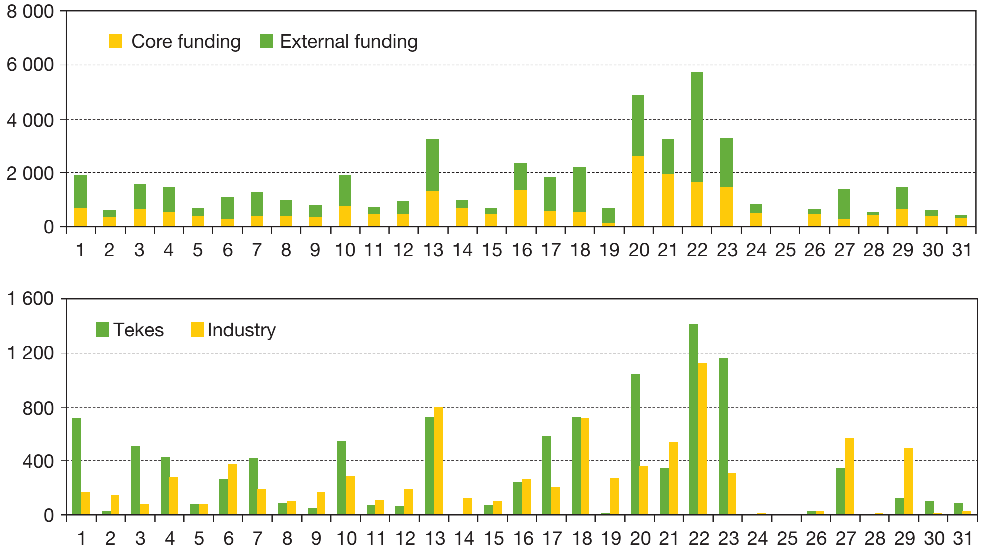


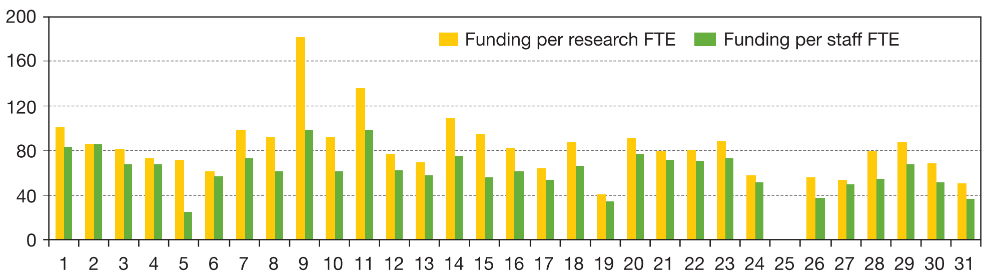
Figure 7. Funding percentages for universities and VTT/IndSys.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 8. Average annual funding for university units and the funding from Tekes and industry (k€).

In Figure 9 the total funding is divided by FTEs for research staff and all staff respectively. Part of the variation is certainly due to the fact that the share of personnel costs of total costs varies. The estimation of this share was not requested. In addition to the varying cost intensity of facilities the accounting principles are not the same for all units.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 9. Funding divided by the number of FTEs (all personnel and research staff only).

Table 6 shows the development of total annual funding for university units. The 2001–2002 data is missing for four university units and 2007 data for three units. The missing data (6%) affects the trends somewhat. The total funding 2000–2007 for all units is estimated by filling the missing years with the data of the nearest reported year. There is about a 22 per cent increase during the period. On the other hand, the percentages do not change considerably; the only clear trend is the decrease in Tekes funding compensated by the increase in industry funding.

Figure 10 shows the development of funding for the universities and VTT/IndSys. The values are estimated by filling missing funding data for some units by the nearest reported data. The leap of VTT/IndSys values from 2005 to 2006 is mostly an artefact of the organisational change. The values of 2005–2006 are exact for VTT, while the values 2002–2005 are scope estimates.

Table 6. Annual funding for university units during the evaluation period.

k€	2000	2001	2002	2003	2004	2005	2006	2007
Budget	17,739	18,685	19,746	20,575	21,576	21,511	20,493	18,026
Other core	695	581	513	460	1,468	1,499	1,285	1,856
Total core	18,434	19,266	20,259	21,035	23,044	23,010	21,778	19,882
Academy	1,839	2,116	2,354	1,816	2,096	1,743	1,814	1,703
Tekes	10,656	10,413	9,861	8,676	9,473	10,062	10,260	8,289
Other public	4,442	3,020	3,221	3,746	3,566	3,107	3,291	2,244
Industry	5,703	5,491	6,717	7,985	8,276	9,162	9,298	9,081
Foundations	203	163	315	207	382	404	372	610
EU	1,172	1,421	1,779	2,129	2,347	2,483	2,717	3,456
Other foreign	198	103	126	338	376	206	193	545
Total external	24,213	22,727	24,373	24,898	26,516	27,167	27,945	25,848
Total (reported)	**42,650**	**41,994**	**44,628**	**45,972**	**49,491**	**50,182**	**497,24**	**45,728**
Total (estimated)	**46,330**	**45,674**	**46,088**	**47,432**	**50,951**	**51,642**	**51,184**	**56,311**
Change per year %		**- 1.4**	**0.9**	**2.9**	**7.4**	**1.4**	**- 0.9**	**10.0**
Change from 2000 %		**- 1,4**	**- 0.5**	**2.4**	**10.0**	**11.5**	**10.5**	**21.5**
%	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Budget	42	44	44	45	44	43	41	39
Other core	2	1	1	1	3	3	3	4
Total core	**43**	**46**	**45**	**46**	**47**	**46**	**44**	**43**
Academy	4	5	5	4	4	3	4	4
Tekes	25	25	22	19	19	20	21	18
Other public	10	7	7	8	7	6	7	5
Industry	13	13	15	17	17	18	19	20
Foundations	0.5	0.4	0.7	0.5	0.8	0.8	0.7	1.3
EU	3	3	4	5	5	5	5	8
Other foreign	0.5	0.2	0.3	0.7	0.8	0.4	0.4	1.2
Total external	**57**	**54**	**55**	**54**	**54**	**54**	**56**	**57**

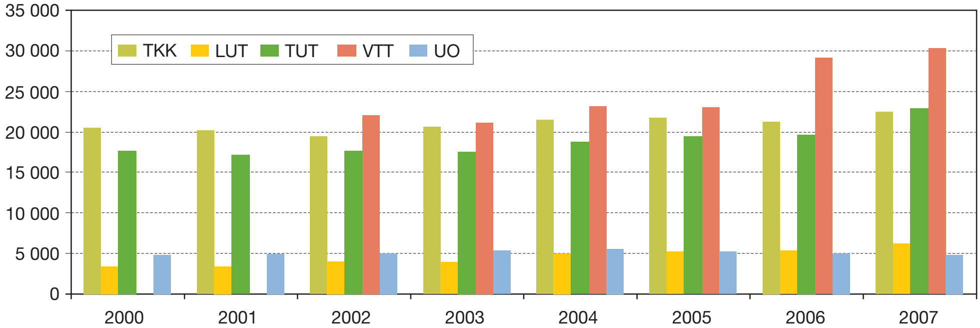


Figure 10. Annual funding of the units in different universities and of VTT/IndSys in 2000–2006.

Table 7. Average annual funding during the evaluation period.

	k€	Total core	Academy	Tekes	Other public	Industry	Foundations	EU	Other foreign	Total external	TOTAL
1	TKK/AutomTech	703	90	712	102	178	0	143	0	1,225	**1,928**
2	TKK/CorrMater	351	1	27	31	148	0	23	0	230	**581**
3	TKK/MaterSci	657	228	515	48	83	45	1	4	924	**1,581**
4	TKK/Metallurgy	550	40	430	0	280	0	160	0	910	**1,460**
5	TKK/ProcHeat	416	10	85	42	79	1	34	2	254	**670**
6	TKK/MaterProc	275	10	262	9	376	1	142	2	802	**1,077**
7	TKK/CombEng	395	72	424	42	193	0	155	0	886	**1,281**
8	TKK/Aerodyn	403	17	89	286	105	0	80	0	577	**980**
9	TKK/Automotive	348	21	58	20	171	0	141	13	424	**771**
10	TKK/EngMater	780	37	553	119	296	9	97	7	1,118	**1,898**
11	TKK/Foundry	504	0	78	0	109	0	13	9	209	**712**
12	TKK/Lightweight	468	0	60	161	188	0	30	49	488	**956**
13	TKK/MachDes	1,340	165	726	168	792	0	38	30	1,919	**3,259**
14	TKK/MechMater	710	45	12	25	126	0	51	2	260	**970**
15	TKK/ProdEng	472	0	73	0	103	0	12	8	196	**668**
16	TKK/Ship	1,361	50	247	97	269	40	254	38	995	**2,356**
17	LUT/MechatrFatig	586	124	585	112	213	0	125	83	1,241	**1,828**
18	LUT/ProdEng	521	23	719	0	716	0	210	0	1,668	**2,188**
19	LUT/WoodTech	169	10	17	97	277	18	78	0	497	**666**
20	TUT/HydrAutom	2,601	387	1,041	405	352	0	62	0	2,247	**4,848**
21	TUT/MechDes	1,973	145	346	187	536	0	39	0	1,252	**3,225**
22	TUT/MaterSci	1,693	216	1,404	1,011	1128	79	214	0	4,052	**5,745**
23	TUT/ProdEng	1,463	78	1,157	88	306	0	173	0	1,802	**3,265**
24	TUT/SafetyEng	533	7	4	241	23	0	3	5	283	**816**
25	VTT/IndSys	7,422	24	3,117	3,330	8,129	0	1,593	1,143	17,334	**24,756**
26	UO/EngMech	476	67	31	11	32	0	7	1	148	**625**
27	UO/Metallurgy	297	89	350	61	566	0	4	0	1,069	**1,366**
28	UO/MachDes	463	0	12	0	18	54	18	0	101	**564**
29	UO/MaterEng	623	41	126	25	493	53	126	7	870	**1,493**
30	UO/Mechatr	413	34	99	0	20	33	0	1	186	**599**
31	UO/ProdTech	327	0	89	0	23	5	1	5	122	**450**

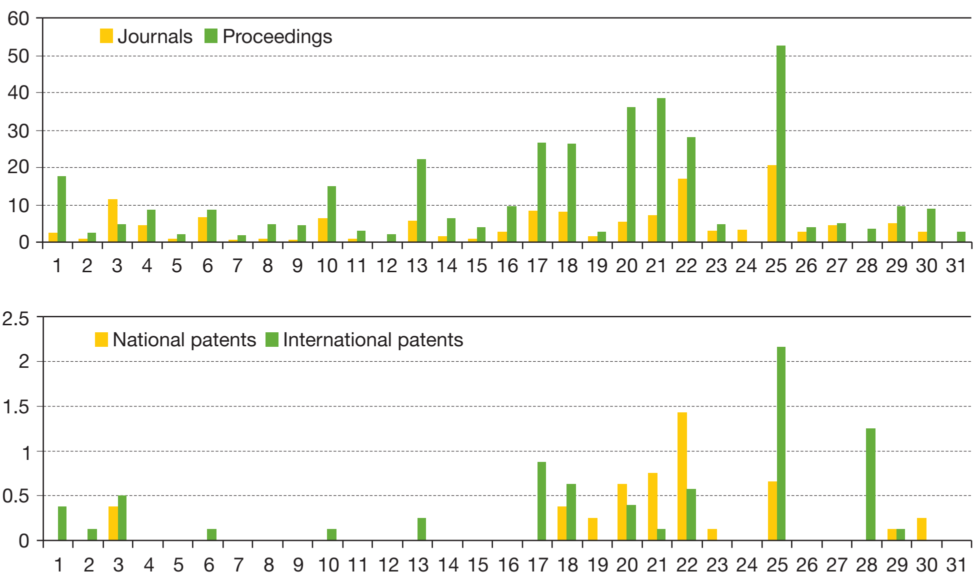
A.6 Publications and other scientific output

The units were asked to provide statistics for various types of scientific publications as well as for patents for each year of the evaluation period. The annual averages are in Table 8 while the detailed data for refereed publications is in Table 23. The total number of articles in journals and proceedings or volumes is 136 and 366 per year respectively, or 4.4 and 11.8 per unit. There are in total 12.6 patents per year, or somewhat less than one patent every second year per unit. The output of the units is illustrated in Figure 11.

The production is in average 0.6 journal or proceeding articles per year and per research FTE, see Figure 12. The same ratio when counting PhDs only is 1.6 for journal and proceeding articles and 0.4 for journal articles only. These are thus upper limits of the publication activity of senior research staff.

In terms of universities only, there are 116 and 313 articles in journals and proceedings respectively, or 3.9 and 10.4 per unit. The production is 0.7 articles per research FTE. The upper limits for PhD researchers are 2.8 articles and 0.8 journal articles per FTE.

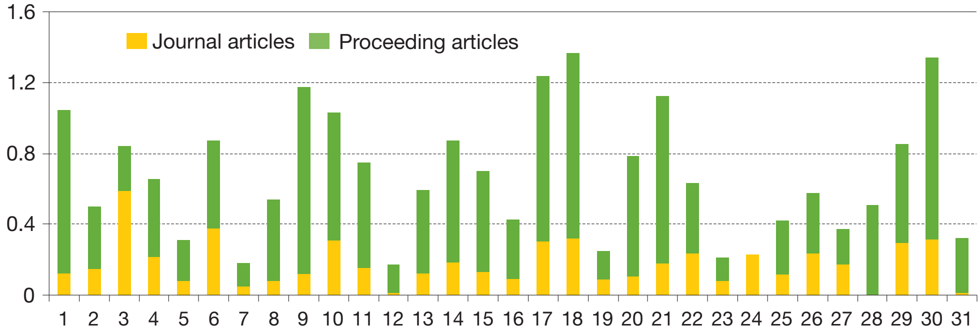
Figure 13 shows the publication statistics for the units at different universities and in VTT. Only the somewhat more efficient publication production of LUT sticks out from the statistics. The change in annual numbers of refereed publications can be studied from Figure 14. VTT is not included, as the data for 2000–2001 is missing.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 11. Refereed publications and patents; per year averages for the evaluation period.

There is an increasing trend during the first three years, after which the production decreases. However, an effort to produce more journal papers can be discerned.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 12. Number of refereed articles per year and per research FTE.

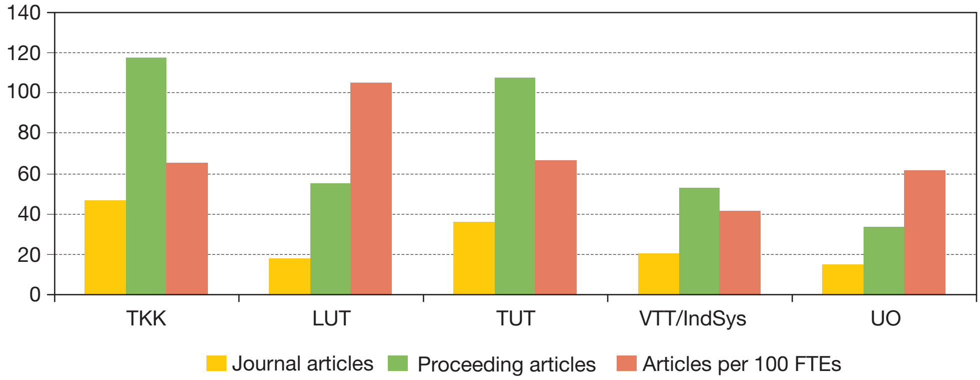


Figure 13. Numbers of refereed publications at the universities (per year); number for publications per 100 research staff FTEs.

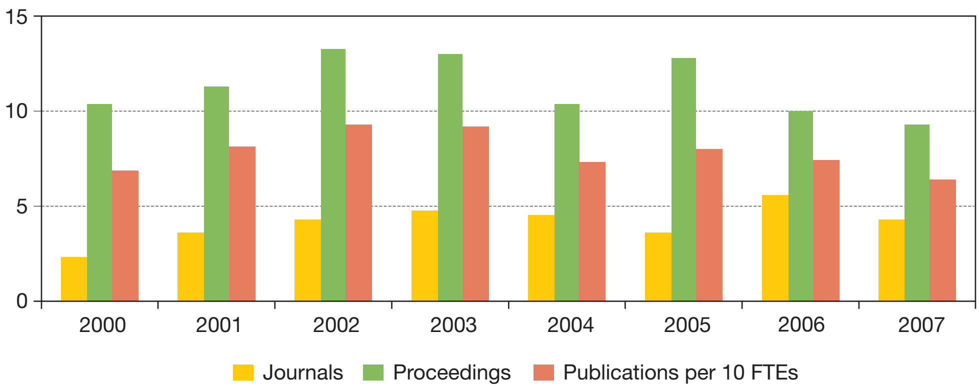


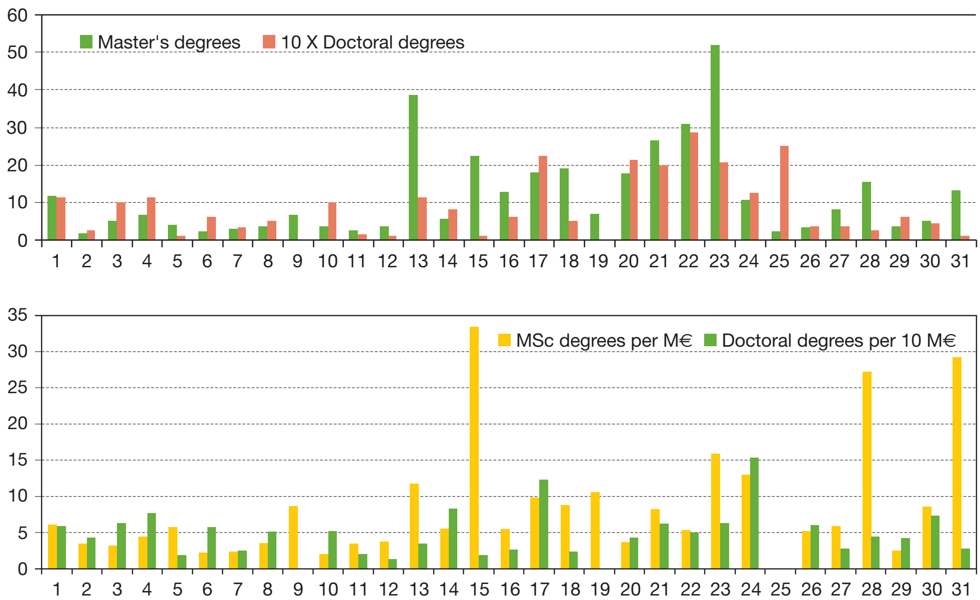
Figure 14. Refereed articles in 2000–2007: average per unit; number of publications per 10 research staff FTEs.

Table 8. Publications and patents; average output per year.

		Articles in refereed journals	Articles in refereed proceedings or other volumes	Monographs, excluding theses	Textbooks and other research-related publications	National patents	International patents	Other scientific publications
1	TKK/AutomTech	2.4	17.6	1.4	0.1	0.0	0.4	0.0
2	TKK/CorrMater	1.0	2.4	0.0	0.1	0.0	0.1	0.6
3	TKK/MaterSci	11.4	4.9	0.0	0.6	0.4	0.5	0.3
4	TKK/Metallurgy	4.4	8.8	0.0	0.1	0.0	0.0	3.8
5	TKK/ProcHeat	0.8	2.1	1.8	0.4	0.0	0.0	4.3
6	TKK/MaterProc	6.6	8.6	0.4	0.0	0.0	0.1	4.8
7	TKK/CombEng	0.6	1.8	0.1	0.5	0.0	0.0	1.9
8	TKK/Aerodyn	0.9	4.9	1.1	0.1	0.0	0.0	0.0
9	TKK/Automotive	0.5	4.5	0.5	0.0	0.0	0.0	9.1
10	TKK/EngMater	6.4	14.9	0.0	0.0	0.0	0.1	6.9
11	TKK/Foundry	0.8	3.1	0.1	6.2	0.0	0.0	0.0
12	TKK/Lightweight	0.1	2.0	0.0	0.1	0.0	0.0	0.4
13	TKK/MachDes	5.8	22.1	0.0	1.4	0.0	0.3	6.3
14	TKK/MechMater	1.6	6.1	0.4	0.4	0.0	0.0	2.9
15	TKK/ProdEng	0.9	4.0	0.1	9.2	0.0	0.0	0.0
16	TKK/Ship	2.6	9.6	0.3	7.4	0.0	0.0	1.1
17	LUT/MechatrFatig	8.5	26.5	0.0	0.1	0.0	0.9	11.6
18	LUT/ProdEng	8.1	26.1	0.0	13.9	0.4	0.6	0.3
19	LUT/WoodTech	1.4	2.6	7.0	0.3	0.3	0.0	7.6
20	TUT/HydrAutom	5.5	36.1	0.0	0.8	0.6	0.4	9.9
21	TUT/MechDes	7.3	38.6	0.0	0.8	0.8	0.1	9.3
22	TUT/MaterSci	17.0	28.1	0.0	0.3	1.4	0.6	25.3
23	TUT/ProdEng	2.9	4.9	0.9	0.4	0.1	0.0	22.4
24	TUT/SafetyEng	3.3	0.0	1.3	6.0	0.0	0.0	10.0
25	VTT/IndSys	20.5	52.7	2.4	10.0	0.7	2.2	36.0
26	UO/EngMech	2.6	3.9	0.0	0.1	0.0	0.0	2.3
27	UO/Metallurgy	4.5	5.0	9.4	0.0	0.0	0.0	0.0
28	UO/MachDes	0.0	3.6	0.6	0.3	0.0	1.3	1.9
29	UO/MaterEng	5.0	9.5	0.3	0.0	0.1	0.1	4.3
30	UO/Mechatr	2.8	9.0	0.4	1.1	0.3	0.0	2.4
31	UO/ProdTech	0.1	2.8	0.0	0.0	0.0	0.0	1.3
Total		136.1	366.8	28.2	60.6	5.0	7.6	186.4
Average per unit		4.4	11.8	0.9	2.0	0.2	0.2	6.0

A.7 Education

The units were asked to provide basic statistics on students and degrees for each year of the evaluation period 2000–2007. The annual data on completed degrees is in Table 24 and the average per year degree production is in Figure 15. On average, there are ten MSc degrees and 0.7 doctoral degrees per unit per year, and the time to complete the MSc degree is about seven years. There are on average 13 MSc degrees per one PhD degree, while the Finnish overall average is about nine, and the range is from 4 to 180. Comparing the degree production to total funding at the universities, each one million euros of funding corresponds on average to 7.5 MSc degrees, and each ten million euros corresponds to five doctoral degrees. These numbers for units are shown in Figure 15 as well.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 15. Master's and doctoral degrees, average per year; number of degrees in relation to total funding.

During the evaluation period, the PhD production fluctuates around a slightly increasing trend, see Figure 16. The number of MSc degrees, on the other hand, has increased considerably during the latter half of the evaluation period. The total number of MSc and PhD degrees from the evaluation period is about 2,900 and 200 respectively.

As regards the present occupation of those who obtained their PhD from the units, 45 per cent have chosen an academic position, 26 per cent have stayed in the unit and 38 per cent are in companies, see Figure 17.

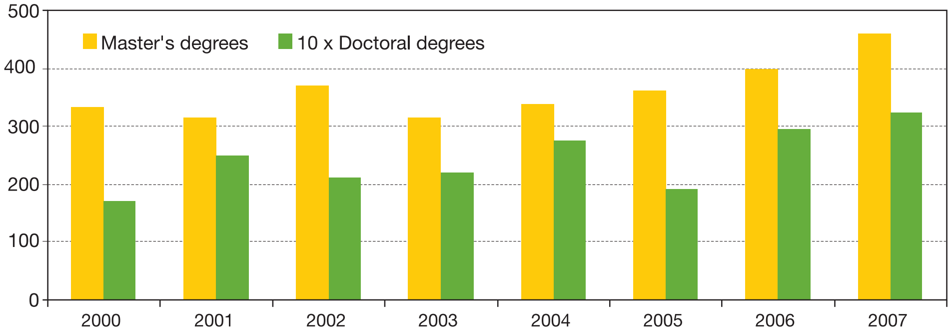


Figure 16. Number of Master's and doctoral degrees during the evaluation period.

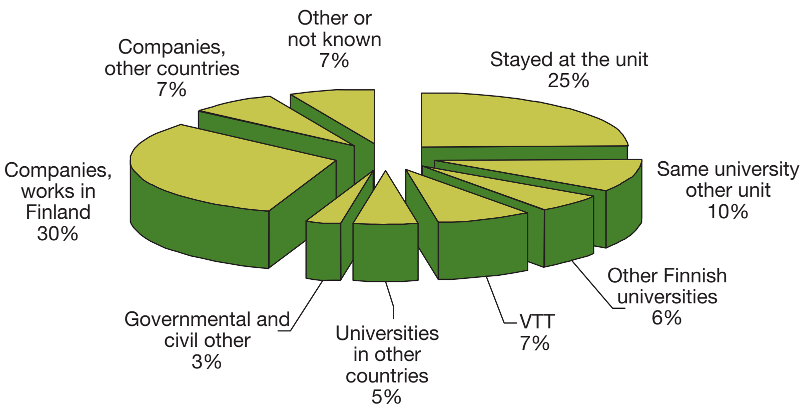


Figure 17. Present employment of people who obtained a PhD degree from units at universities.

The median year of birth when completing a doctoral degree is 1968. By taking the middle of the evaluation period the median age when completing is estimated to 35. The range in year of birth is 1936–1980, and the percentage of women is 15 per cent. The average time-to-degree is six years, the range being 2–16 years.

Using the average time to complete a Master's degree, seven years, the average time to complete both Master's and doctoral degrees is 13 years. Subtracting this from the median age 35 years leaves 22 years or considerably higher than the average age

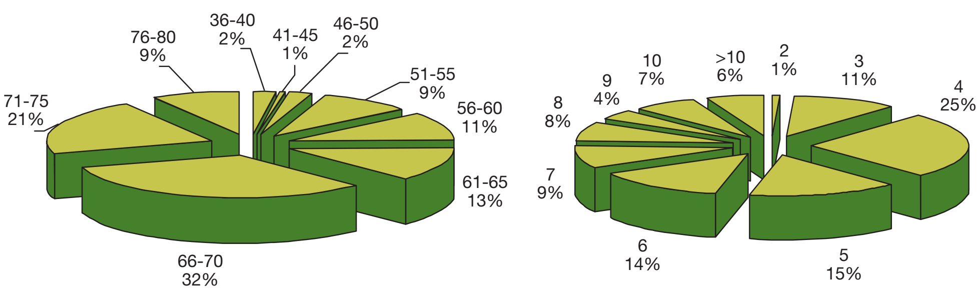


Figure 18. Distribution of year of birth for doctors completing the degree during the evaluation period (8 years); the distribution of time-to-degree.

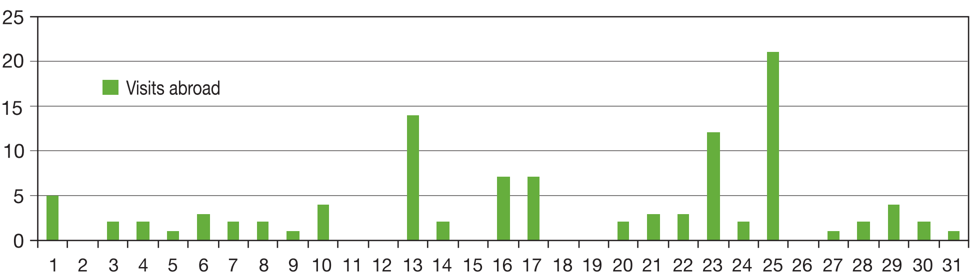
when starting studies. This is indicative of the fact that doctoral studies are often commenced after a period in industry or otherwise outside the academic world. The distribution of year of birth when completing the doctoral degree and the time-to-degree are given in Figure 18. The former is, of course, influenced by the fact that the cases are spread over eight years: older doctoral students are more likely to have obtained their degree during the first years of the evaluation period, and vice versa for younger doctoral students.

A.8 National and international collaboration

The units were asked to fill in detailed tables on visits to and from the units, on domestic and foreign research collaboration, and on non-scientific collaboration. The minimum visit time was set to one month and the units could also provide a table on short important visits. The criteria for collaboration was that it should result in research output, that is, articles, patents or other scientific end-products. However, units applied widely variable criteria and also much of the data was missing. Thus, the data do not allow much quantitative comparing.

Domestic collaboration generally seeks to be long-term; only in few cases has the collaboration ceased after 1–2 years. On average nine foreign collaborators per unit are listed, and from the sparse data the average allocation therefrom is ten months per collaborator. About 10 per cent of the collaborators are industrial companies. The results are mostly standard results of research collaboration, usually associated with MSc and PhD degrees.

As concerns longer visits abroad from the unit, 26 units report on average 4.2 visits by 3.8 researchers to 3.2 different organisations. Thus, the same names for visitors and visited organisations are not repeated often. There are on average 1.1 longer visits per listed researcher during the whole period 2000–2007 and the average visit duration is 7.5 months, so that the bulk of the visit months is likely to be due to postgraduate studies. Two units have had a visiting professor post abroad. The visits abroad data are shown in Figure 19.



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

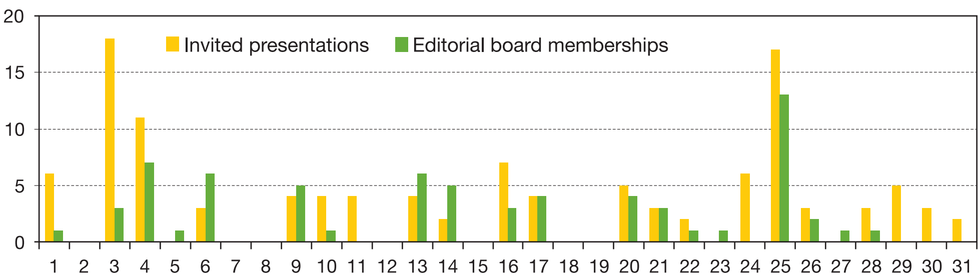
Figure 19. Visits abroad from the units (zero value = no data).

As concerns longer visits to the unit, 24 units report on average eleven visits per unit and 1.3 visits per foreign organisation. The average visit length is 12.3 months. It is again apparent that this is due to foreign postgraduate students and, more prominently, to MSc students.

The geographic distribution of the collaboration can be studied from Table 9. It is seen that organisations in the US, Central Europe, Sweden and Japan account for most of the collaboration. However, although the US has the second largest share of collaborating organisations (28) and is the most popular target country for visits (42), there are only six visits from the US to the units. Central European countries and Japan are more in balance in this respect, while, on the other hand, there are few visits to and from Sweden, which is number three on the collaborators list. The numbers reflect the fact that a large fraction of visits to the unit are related to graduate and postgraduate studies.

Table 9. Geographic distribution of collaboration.

Visits abroad		Visits to the unit		Collaborators	
USA	42	FRA	30	GER	30
GER	19	ESP	25	USA	28
JPN, NED	6	GER, POL	19	SWE	22
UK	6	JPN, UKR	17	JPN	20
AUT, FRA, POL	4	MEX	13	UK	19
ITA, SWE	2	CHN, CZE	12	FRA	12
CAN, DEN, ESP, SUI	2	UK, HUN, RUS	7	BEL	11
BEL, CHN, IRL, SIN	1	USA	6	POL, ITA	7
		CAN	5	HUN, CZE	6
		ROM	4	UKR, NED	5
		CRO, EST, IRL, NED, PAK, POR, SUI	3	AUT, DEN, ESP, RUS	4
		AUT, EGY, IND, KOR, SLO	2	CAN, SLO	3
		ARG, AUS, BAN, BRA, BUL, CUB, CYP, GRE, LTU, MLT, MON, NIG, RSA, SIN, SWE	1	CRO, IND, NOR, SUI	2
				ARG, CHN, LAT, LTU, MEX, TAI	1



TKK	5 ProcHeat	10 EngMater	15 ProdEng	19 WoodTech	23 ProdEng	27 Metallurgy
1 AutomTech	6 MaterProc	11 Foundry	16 Ship	**TUT**	24 SafetyEng	28 MachDes
2 CorrMater	7 CombEng	12 Lightweight	**LUT**	20 HydrAutom	25 **VTT**/IndSys	29 MaterEng
3 MaterSci	8 Aerodyn	13 MachDes	17 MechatrFatig	21 MechDes	**UO**	30 Mechatr
4 Metallurgy	9 Automotive	14 MechMater	18 ProdEng	22 MaterSci	26 EngMech	31 ProdTech

Figure 20. Invited presentations and editorial board memberships.

The units were also asked to provide lists on invited presentations, important memberships or positions of trust, prizes and honours. From this data, invited presentations and editorial board memberships are shown in Figure 20; others apply criteria too variable to allow comparison.

Table 10. Personnel statistics: professors and other senior scientists.

	FTEs	Professors								Other senior researchers							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	1	1	2	2	2	2	2	2	1	1	1	3	3	4	4	4
2	TKK/CorrMater	1	1	1	1	1	1	1	1	4	3	3	1	1	1	3	2
3	TKK/MaterSci	1	1	1	1.9	2	2	2	3	2	2	2	2	2.1	2.8	3.3	3.7
4	TKK/Metallurgy	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	3
5	TKK/ProcHeat	2	2	1	1	1	1	1	1	2	1	2	2	2	2	2	2
6	TKK/MaterProc	1	1	1	1	1	1	1	1	1	1	1	0.6	1	1	1	1
7	TKK/CombEng	1	1	1	1	1	1	1	1	0	0	0.5	0.5	0.5	0	0	0
8	HUT/Aerodyn	1	1	1	1	1	1	1	1	1.8	1.8	1.7	0.8	0.8	0.8	0.8	0.8
9	TKK/Automotive	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
10	TKK/EngMater	1	1	1	1	1	1	1	1	2	2	3	3.5	4.8	4	3	3
11	TKK/Foundry	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
12	TKK/Lightweight	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
13	TKK/MachDes	4	4	4	3.8	4	4	4	4	1	1	1	3	3	3	4	4
14	TKK/MechMater	0.8	1.6	1.8	1.8	1.9	1.8	1.8	2	1	1	1	1	2	2	2	1
15	TKK/ProdEng	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
16	TKK/Ship	4	4	3.9	4	3.7	3.1	3.4	4	0	0	0.5	0	0.6	1.1	0.8	0
17	LUT/MechatrFati	4	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0
18	LUT/ProdEng	3	3	3	3.5	5	5	5	5	2	2	2	1	1	1	1	1
19	LUT/WoodTech	1	1.7	2.8	3	3	3	3	2.3	1	1	1	1	1	1	0.5	0
20	TUT/HydrAutom	4	4	4	4.8	5.8	6	6	6	4.5	4.4	3.9	3	3	3	3	3
21	TUT/MechDes	6.3	7.6	7	6	6	6	6	6	0.2	0.2	1.2	1.2	1.2	1.2	1.2	1.2
22	TUT/MaterSci	6	6	6	6	7	9	7	7	2	2	2	2	2	2	2	2
23	TUT/ProdEng	6	6	5	5	5	7	6	6	0	0	0	0	0	0	0	0
24	TUT/SafetyEng	1	1	1	1	1.8	2	2	2	0	0	0	0	0	0	0	0
25	VTT/IndSys	0	0	3	3	2	2	3	4	0	0	146	136	134	138	160	147
26	UO/EngMech	2	2	2	2	2	2	1.9	2	1	1	1	1	1	1	1	0
27	UO/Metallurgy	1	1	1	1	1	1	1	1	1	1	1	1.4	1.7	2	2.5	2.5
28	UO/MachDes	2.9	3	3	2.8	2	2	2	2	0.6	0	0	0	0	0	0	0
29	UO/MaterEng	2	2	2	2.3	3	3	3	3	2	2	2	2	1.7	1	1	1
30	UO/Mechatr	3.4	3.5	3.1	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	0.3
31	UO/ProdTech	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
	TOTAL	68	70	73	73	76	79	78	80	31	28	178	167	168	173	197	180
	TOTAL – VTT	68	70	70	70	74	77	75	76	31	28	32	31	34	35	37	33

Table 11. Personnel statistics: postdoctoral researchers and postgraduate students.

	FTEs	Postdoctoral researchers								Postgraduate students							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	4	4	4	3	3	2	2	2	10	10	10	10	10	11	12	12
2	TKK/CorrMater	0	0	0	0	0	0	0	0	3	4	6	6	4	2	4	3
3	TKK/MaterSci	2	0	0	0.3	1	1.8	2	2.7	8.3	8	8.6	7.1	7.4	5.8	5.6	3.8
4	TKK/Metallurgy	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	12
5	TKK/ProcHeat	1	0	0	0	0	0	0.3	0.3	6	6	7	6	6	6	5.3	5.3
6	TKK/MaterProc	2	2	2	2	2	3	2	2.6	9.7	8.3	7	8.3	7.8	10	10.5	12
7	TKK/CombEng	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	3
8	TKK/Aerodyn	0.2	0	0	0	0.8	1	1	1.7	1.8	2	2.8	3.3	3	2.4	1.6	1.2
9	TKK/Automotive	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2
10	TKK/EngMater	4.2	2	3.3	4.5	3.5	2.5	2	1.8	14.3	12.7	9.9	12.7	13.3	16	12.2	10.8
11	TKK/Foundry	0	0	0	0	0	0	0.2	1	0	0	0	1	1	3	2.7	2
12	TKK/Lightweight	0	0	0	0	0	0	0	0	0	0	0	1	0.3	0.6	0.2	0.5
13	TKK/MachDes	2	2	2	1	1	2.3	2	2.5	23.6	16.8	15.5	18.3	20	19.1	16.3	16.3
14	TKK/MechMater	1	1	1	1	1	0.5	0	0	2	2	2	3.7	4	4.2	4.9	4
15	TKK/ProdEng	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
16	TKK/Ship	3	2	1	1.4	1	1.3	1.3	0.3	5	8	11.5	11.9	11	10.8	8	8.8
17	LUT/MechatrFatig	6.7	6.7	6.7	8.3	8.3	10	10	10	15	15	15	15	15	16.7	16.7	18
18	LUT/ProdEng	1	2	3	4	3	3	3	4	10	10	10	11	14	15	15	16
19	LUT/WoodTech	0	0	0	0	0	0.8	1	1	2	4	4	4	16	16	20	20
20	TUT/HydrAutom	4.4	6.6	8.9	8	7.4	6.1	5	6.3	24.8	26.9	31.8	27.7	30.3	30.9	30.8	35.8
21	TUT/MechDes	0	0	1	2.4	3.1	3.6	4.8	6	21.4	17.1	18	19	27.8	8.4	13.5	16
22	TUT/MaterSci	0	0	1	1	3	3	3	3	53	46	41	42	51	56	60	56
23	TUT/ProdEng	1	1	1	0	0	1.3	2.3	4.7	22	25	25	24	28	28	30	29
24	TUT/SafetyEng	0	0	0	0	0	0	0	0	14	12	12	14	13	10	12	8
25	VTT/IndSys	0	0	19	20	21	24	35	35	0	0	0	0	0	0	0	0
26	UO/EngMech	1	1	1	1	1	1	0	1	1	1	2	0.6	1	1	1	2
27	UO/Metallurgy	0	1	1.4	2	1.4	2.5	2.5	3	6	8	9.2	8.3	6.9	6	7.2	5.8
28	UO/MachDes	0	0	0	0	0	0	0	0	2	2.3	3	3.3	3.5	3.7	4	3.6
29	UO/MaterEng	0.3	0.3	0	0	0.2	0	0	0.1	6	6	5	7	6	7	8	6
30	UO/Mechatr	0	0	0	0	0	0	0.6	1	1.7	1.9	4.9	7.2	7.2	7.6	5.3	5.6
31	UO/ProdTech	0	0	0	0	0	0	0	0	3	2.7	2	2	2	2	3	3
	TOTAL	132	130	307	299	306	322	355	351	270	260	267	278	315	304	316	312
	TOTAL – VTT	132	130	139	140	149	158	157	165	270	260	267	278	315	304	316	312

Table 12. Personnel statistics: other academic staff, and visiting researchers and visiting research students.

	FTEs	Other academic staff								Visiting researchers and visiting research students							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	1	1	1	1	1	1	1	1	0	1	0	1	0.3	0.3	2	2
2	TKK/CorrMater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	TKK/MaterSci	7.7	4.7	5.7	8.8	5.2	3.8	5	9.5	0.5	1	0.2	0	0	1.4	2.4	1.6
4	TKK/Metallurgy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
5	TKK/ProcHeat	0	0	0	0	0	0	0	0	0.5	0.3	0	0	0	0	0	0
6	TKK/MaterProc	5	5	5.4	4.2	3.3	3	2.5	3	0	0.2	0.3	0.9	0.4	0	0	0.3
7	TKK/CombEng	14.2	12.6	11.4	11.8	9.8	8.6	6.1	8.4	0	0.3	0	0	0.6	0	0	0
8	TKK/Aerodyn	1.8	3.7	3.7	3.7	3.3	3.3	3.5	3.3	2.5	2.8	3	2	2.3	2.2	2.6	2.2
9	TKK/Automotive	1	3	3	3	3	2	2	2	0	0.5	0	0.5	0.5	0.5	1	0
10	TKK/EngMater	1	1	1	1	1	1	1	1	1	3.9	3.6	4.6	3.8	2.4	3.3	3
11	TKK/Foundry	2	2	3	3	3	3	3	3.8	0	0	0	0	0.5	0	0	0
12	TKK/Lightweight	12.1	9.3	10.1	11.2	11.6	11.8	9.4	10.2	0.7	0.9	0.8	0.2	0.4	0.5	0	0.2
13	TKK/MachDes	11.4	16.3	19.3	19.6	20.2	22.3	26.1	26.1	0.3	0	0.3	1.3	0	0.3	1.3	0.7
14	TKK/MechMater	2	2	2	2	1.5	1	1	1	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.4
15	TKK/ProdEng	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
16	TKK/Ship	18.3	14.4	12.8	11.3	10.4	10.2	10.4	14.4	0	0	0.2	0.2	1.3	2.9	1.8	0.8
17	LUT/MechatrFatig	0	0	0	0	0	0	0	0	0.2	0.3	0	0	0	0	0	0.8
18	LUT/ProdEng	4	4	4	4	4	4	4	4	0	0	0.3	0.3	0	0	0	0.4
19	LUT/WoodTech	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
20	TUT/HydrAutom	0	0	0	0	0	0	0	0	3.2	4	5.8	5.7	5.3	4.2	4.6	4.8
21	TUT/MechDes	13.5	9.3	8.3	11.4	10.5	10.8	9	10.1	3.6	3.4	5	5.3	1.8	1.8	1.7	1.4
22	TUT/MaterSci	6	6	6	6	7	7	6	6	5	5	4	5	4	4	3	4
23	TUT/ProdEng	4	13	14	8	5	4	6	5	0	0	0	0	0	0.3	0.3	0.3
24	TUT/SafetyEng	0	0	0	0.2	0.3	1	1	1	1.5	0.4	0.2	0.2	0.2	0.2	0.2	0.2
25	VTT/IndSys	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	7
26	UO/EngMech	5.5	5.4	5	3	4	5	6.8	5	0.7	0	0.3	0.2	0.3	0	0	0
27	UO/Metallurgy	10	13.7	12.5	11	10.8	11.3	9.3	9.2	0	0	0	0	0	0	0	0
28	UO/MachDes	0	0	0.8	1	0.8	0	0.8	1	0	0	0	0	0	0	0	0
29	UO/MaterEng	3	3	3	4	3.3	6	4	7.5	0.3	0.2	0	0	0	0	0	0
30	UO/Mechatr	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
31	UO/ProdTech	2.7	2.1	2.6	3.1	5.4	5.7	3	2.8	0.3	0	0	0	0	0	0	0
	TOTAL	130	135	138	136	129	130	125	139	20	25	25	28	23	22	26	30
	TOTAL – VTT	130	135	138	136	129	130	125	139	20	25	24	27	22	21	24	23

Table 13. Personnel statistics: total active research staff.

	FTEs	Total active research staff							
		2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	17	18	18	20	19.3	20.3	23	23
2	TKK/CorrMater	7.5	7.5	9.5	7.5	5.5	3.5	7.5	5.5
3	TKK/MaterSci	21.5	16.7	17.4	20.1	17.7	17.5	20.3	24.3
4	TKK/Metallurgy	0	0	0	0	0	0	0	20.1
5	TKK/ProcHeat	11.5	9.3	10	9	9	9	8.7	8.7
6	TKK/MaterProc	18.7	17.3	16.8	17	15.6	18	17	19.9
7	TKK/CombEng	16.2	14.6	13.9	14.3	12.3	10.6	9.1	13.4
8	TKK/Aerodyn	9.1	11.2	12.1	10.7	11.2	10.7	10.4	10.1
9	TKK/Automotive	2	4.5	4	4.5	5.5	4.5	5	4
10	TKK/EngMater	18.6	19.6	18	22.3	22.3	24.4	20.5	18.8
11	TKK/Foundry	3	3	4	5	5.5	7	6.8	7.8
12	TKK/Lightweight	13.8	11.2	11.8	13.3	13.3	13.8	10.6	11.8
13	TKK/MachDes	42.2	40.1	42.1	46.8	48.2	51	53.7	53.5
14	TKK/MechMater	7.1	7.8	8	9.7	10.6	9.7	10	8.4
15	TKK/ProdEng	7	7	7	7	7	7	7	7
16	TKK/Ship	30.3	28.4	29.8	28.8	28	29.3	25.8	28.4
17	LUT/MechatrFatig	25.8	25.9	25.7	27.3	27.3	30.7	30.7	32.8
18	LUT/ProdEng	20	21	22.3	23.8	27	28	28	30.4
19	LUT/WoodTech	6	8.7	9.8	10	22	22.8	26.5	25.3
20	TUT/HydrAutom	35.6	39.7	53.3	48.8	53.3	63.3	60.8	69.9
21	TUT/MechDes	45	37.6	40.4	45.3	50.4	31.8	36.2	40.7
22	TUT/MaterSci	72	65	60	62	74	81	81	78
23	TUT/ProdEng	33	45	45	37	38	40.5	44.6	44.9
24	TUT/SafetyEng	16.5	13.4	13.2	15.3	15.3	13.2	15.2	11.2
25	VTT/IndSys	0	0	169	160	158	166	200	193
26	UO/EngMech	10.5	10.4	11	7.6	9	10	10.7	10
27	UO/Metallurgy	18	24.7	25.1	23.8	21.8	22.8	22.4	21.5
28	UO/MachDes	5.5	5.3	6.8	7	6.4	5.7	6.8	6.6
29	UO/MaterEng	13.7	13.4	12	15.3	14.2	17	16	17.6
30	UO/Mechatr	5.2	5.9	8	8.7	8.7	9.1	7.5	8.3
31	UO/ProdTech	8	6.8	6.6	7.1	9.4	9.7	8	7.8
	TOTAL	540	539	731	735	766	788	830	863
	TOTAL – VTT	540	539	562	575	608	622	630	670

Table 14. Personnel statistics: administrative and technical personnel.

	FTEs	Administrative personnel								Technical personnel							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	3	3	3	3	3
2	TKK/CorrMater	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	TKK/MaterSci	2	2	2	2	2	1.6	1	1	3.8	3	3	2	2	2	2	2
4	TKK/Metallurgy	0	0	0	0	0	0	0	0.8	0	0	0	0	0	0	0	1
5	TKK/ProcHeat	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0
6	TKK/MaterProc	0.2	0.3	1	1	1	1	1	1	0.5	0.5	0.6	0.6	0.5	0.5	0.7	0.5
7	TKK/CombEng	1	1	1	1	1	1	1	1	4	4	4	4	4	3	3	3
8	TKK/Aerodyn	2	2	2	2	1.6	1.6	2	2	3.7	3.7	3.7	3.7	3.7	3.7	3.5	3.1
9	TKK/Automotive	1	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3
10	TKK/EngMater	1.1	0.3	0.7	0.7	0.9	1.1	1	1	13.1	14	8.2	8.7	8.6	8.3	8	8.5
11	TKK/Foundry	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2
12	TKK/Lightweight	1	1	0.9	0.8	0.8	0.8	0.8	0.8	3	2.7	2.5	2.3	2.5	1.5	1.5	1.5
13	TKK/MachDes	3.3	3.3	3.3	3	3	3	3	3	5	5.3	6	7	6.7	6	6	6
14	TKK/MechMater	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3
15	TKK/ProdEng	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3
16	TKK/Ship	2	2	2	2	3	2	2	2	8	8	8	8	8	8	9	9
17	LUT/MechatrFatig	0	0	0	0	0	0	0	0	6	6	6	6	6	6	6	6
18	LUT/ProdEng	0	0	0	0	0	0	0	0	8	8	8	8	8	8	8	8
19	LUT/WoodTech	0	0	0	0	0	0	0	1	0	0	2	2	3	3	3	3
20	TUT/HydrAutom	1	1	1	1.6	2	2	2	2	6	6	6	6	6	6	6	6
21	TUT/MechDes	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	TUT/MaterSci	3	3	3	3	3	3	4	4	6	7	7	7	7	7	7	7
23	TUT/ProdEng	2	2	2	2	2	2	2	2	9	4	4	9	7	5	4	4
24	TUT/SafetyEng	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0
25	VTT/IndSys	0	0	35	31	31	26	7	8	0	0	75	55	55	54	55	53
26	UO/EngMech	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	5	5	5	5	5	4	4	4
27	UO/Metallurgy	1	1	1	1	1	1.2	1.3	1.3	1	1	1	1	1	1	1	1
28	UO/MachDes	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	3.6	3.2	2.4	2.4	2.2	2.2	2.1	2
29	UO/MaterEng	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.5	5	5	5	5	4	4	4.4
30	UO/Mechatr	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	3.3	2.7	1.9	1.9	1.9	1.6	1.5	1.4
31	UO/ProdTech	1	1	1	1	1	1	1	1	3	3	3	3	3	2	2	2
	TOTAL	34	34	70	66	68	61	43	46	113	108	178	166	162	153	153	152
	TOTAL – VTT	34	34	35	35	37	35	36	38	113	108	103	111	107	99	98	99

Table 15. Total core funding.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	600	650	664	664	750	731	863	0
2	TKK/CorrMater	0	0	309	326	345	383	406	337
3	TKK/MaterSci	569	591	443	639	786	739	781	706
4	TKK/Metallurgy	0	0	0	0	0	0	0	550
5	TKK/ProcHeat	471	420	323	378	391	539	407	400
6	TKK/MaterProc	243	241	263	279	308	271	275	320
7	TKK/CombEng	0	0	337	367	489	374	395	405
8	TKK/Aerodyn	380	380	380	429	436	412	398	407
9	TKK/Automotive	300	348	333	325	396	355	377	0
10	TKK/EngMater	687	654	706	742	685	998	865	903
11	TKK/Foundry	316	316	316	332	316	312	306	304
12	TKK/Lightweight	389	443	424	521	600	532	446	388
13	TKK/MachDes	1,198	1,263	1,408	1,331	1,331	1,479	1,327	1,386
14	TKK/MechMater	566	605	695	653	824	793	774	766
15	TKK/ProdEng	474	474	474	498	474	468	458	456
16	TKK/Ship	1,146	1,152	1,078	1,482	1,454	1,425	1,512	1,635
17	LUT/MechatrFatig	530	543	621	560	648	607	698	484
18	LUT/ProdEng	620	605	602	526	506	463	407	435
19	LUT/WoodTech	0	0	143	179	170	143	212	168
20	TUT/HydrAutom	2,442	2,465	2,411	2,273	2,988	2,947	2,482	2,800
21	TUT/MechDes	1,829	1,955	1,923	1,968	2,236	1,950	1,691	2,228
22	TUT/MaterSci	1,618	1,593	1,857	1,954	1,989	2,283	2,248	0
23	TUT/ProdEng	1,302	1,612	1,315	1,279	1,456	1,462	1,244	2,031
24	TUT/SafetyEng	475	395	469	508	591	586	560	683
25	VTT/IndSys	0	0	7,214	6,518	6,530	7,499	8,023	8,748
26	UO/EngMech	401	419	516	483	531	530	460	470
27	UO/Metallurgy	250	290	310	291	320	329	324	263
28	UO/MachDes	346	471	554	569	520	491	456	300
29	UO/MaterEng	551	735	693	710	695	621	631	345
30	UO/Mechatr	310	403	415	468	449	448	444	365
31	UO/ProdTech	421	243	277	301	360	339	331	347
	TOTAL	**18,434**	**19,266**	**27,473**	**27,553**	**29,574**	**30,509**	**29,801**	**28,630**
	TOTAL – VTT	**18,434**	**19,266**	**20,259**	**21,035**	**23,044**	**23,010**	**21,778**	**19,882**

Table 16. Funding from the Academy of Finland.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	90	100	102	98	87	96	57	0
2	TKK/CorrMater	0	0	0	0	5	0	0	0
3	TKK/MaterSci	259	375	196	285	123	106	184	295
4	TKK/Metallurgy	0	0	0	0	0	0	0	40
5	TKK/ProcHeat	3	80	0	0	0	0	0	0
6	TKK/MaterProc	17	4	5	31	14	5	0	0
7	TKK/CombEng	0	0	37	36	330	-	-	29
8	TKK/Aerodyn	40	0	0	0	0	0	15	80
9	TKK/Automotive	8	2	33	22	0	17	62	0
10	TKK/EngMater	36	46	84	0	0	46	42	43
11	TKK/Foundry	0	0	0	0	0	0	0	0
12	TKK/Lightweight	0	0	0	0	0	0	0	0
13	TKK/MachDes	128	174	122	72	149	252	279	146
14	TKK/MechMater	8	2	29	17	40	14	88	159
15	TKK/ProdEng	0	0	0	0	0	0	0	0
16	TKK/Ship	41	123	141	97	0	0	0	0
17	LUT/MechatrFatig	92	80	71	188	209	176	73	100
18	LUT/ProdEng	0	0	92	45	0	0	0	43
19	LUT/WoodTech	0	0	0	0	0	0	0	60
20	TUT/HydrAutom	516	329	625	432	299	304	420	172
21	TUT/MechDes	100	63	57	68	349	211	134	176
22	TUT/MaterSci	146	358	350	158	243	270	201	0
23	TUT/ProdEng	42	158	197	136	64	23	0	5
24	TUT/SafetyEng	11	0	0	0	0	0	0	43
25	VTT/IndSys	0	0	1	1	15	19	43	66
26	UO/EngMech	141	92	132	50	36	43	41	0
27	UO/Metallurgy	84	40	0	0	148	113	135	194
28	UO/MachDes	0	0	0	0	0	0	0	0
29	UO/MaterEng	67	51	42	48	0	41	45	30
30	UO/Mechatr	10	39	39	33	0	26	38	88
31	UO/ProdTech	0	0	0	0	0	0	0	0
	TOTAL	**1,839**	**2,116**	**2,355**	**1,817**	**2,111**	**1,762**	**1,857**	**1,769**
	TOTAL – VTT	**1,839**	**2,116**	**2,354**	**1,816**	**2,096**	**1,743**	**1,814**	**1,703**

Table 17. Funding from Tekes.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	550	550	584	557	844	963	939	0
2	TKK/CorrMater	0	0	20	11	55	74	0	0
3	TKK/MaterSci	847	855	484	385	174	268	452	658
4	TKK/Metallurgy	0	0	0	0	0	0	0	430
5	TKK/ProcHeat	183	11	0	0	53	135	116	185
6	TKK/MaterProc	381	342	302	165	186	238	282	200
7	TKK/CombEng	0	0	761	505	465	387	217	210
8	TKK/Aerodyn	60	70	59	94	105	111	126	85
9	TKK/Automotive	21	24	77	115	69	68	35	0
10	TKK/EngMater	973	820	305	427	532	442	457	464
11	TKK/Foundry	80	80	75	40	60	17	8	28
12	TKK/Lightweight	86	0	100	40	73	150	15	15
13	TKK/MachDes	701	870	718	696	792	572	699	761
14	TKK/MechMater	21	24	0	13	8	6	10	14
15	TKK/ProdEng	120	120	113	60	90	26	12	42
16	TKK/Ship	495	476	300	1	117	150	282	158
17	LUT/MechatrFatig	320	320	480	575	763	728	776	720
18	LUT/ProdEng	800	700	806	653	727	738	648	677
19	LUT/WoodTech	0	0	50	0	0	50	0	0
20	TUT/HydrAutom	1,321	1,047	1,004	1,216	826	1,141	942	828
21	TUT/MechDes	252	304	379	240	244	384	463	500
22	TUT/MaterSci	1,359	1,740	1,611	1,465	1,580	1,566	1,913	0
23	TUT/ProdEng	1,098	1,060	1,008	828	1,039	1,029	1,317	1,880
24	TUT/SafetyEng	0	0	0	0	0	8	21	4
25	VTT/IndSys	0	0	2,762	2,000	2,619	2,793	3,698	4,827
26	UO/EngMech	57	82	41	49	13	2	6	0
27	UO/Metallurgy	581	567	335	269	220	432	263	130
28	UO/MachDes	0	12	19	1	43	2	11	6
29	UO/MaterEng	236	270	35	38	50	100	120	158
30	UO/Mechatr	48	35	62	136	147	158	91	111
31	UO/ProdTech	66	34	133	97	198	117	39	25
	TOTAL	**10,656**	**10,413**	**12,623**	**10,676**	**12,092**	**12,855**	**13,958**	**13,116**
	TOTAL – VTT	**10656**	**10,413**	**9,861**	**8,676**	**9,473**	**10,062**	**10,260**	**8,289**

Table 18. Funding from other public sources.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	50	50	55	83	129	191	154	0
2	TKK/CorrMater	0	0	38	64	52	28	1	0
3	TKK/MaterSci	32	35	57	38	89	86	22	28
4	TKK/Metallurgy	0	0	0	0	0	0	0	0
5	TKK/ProcHeat	36	29	54	90	55	40	34	0
6	TKK/MaterProc	50	0	2	11	4	0	7	0
7	TKK/CombEng	0	0	116	101	27	5	0	0
8	TKK/Aerodyn	250	250	275	360	316	256	313	268
9	TKK/Automotive	28	6	0	10	74	10	12	0
10	TKK/EngMater	156	118	107	292	112	59	58	52
11	TKK/Foundry	0	0	0	0	0	0	0	0
12	TKK/Lightweight	143	134	204	147	182	190	142	150
13	TKK/MachDes	238	166	244	195	89	140	159	114
14	TKK/MechMater	32	58	34	16	14	17	5	24
15	TKK/ProdEng	0	0	0	0	0	0	0	0
16	TKK/Ship	136	113	93	137	116	57	15	108
17	LUT/MechatrFatig	60	110	110	116	116	160	110	110
18	LUT/ProdEng	0	0	0	0	0	0	0	0
19	LUT/WoodTech	0	0	0	100	250	0	180	50
20	TUT/HydrAutom	211	38	82	323	539	641	540	868
21	TUT/MechDes	427	96	50	61	132	170	270	288
22	TUT/MaterSci	1,964	1,442	1,043	1,070	857	793	919	0
23	TUT/ProdEng	27	41	338	156	116	1	23	0
24	TUT/SafetyEng	398	218	214	275	230	204	260	130
25	VTT/IndSys	0	0	2,505	2,636	2,609	2,055	5,349	4,823
26	UO/EngMech	52	0	0	0	0	13	9	12
27	UO/Metallurgy	112	76	85	81	47	26	38	22
28	UO/MachDes	0	0	0	0	0	0	0	0
29	UO/MaterEng	40	40	20	20	20	20	20	20
30	UO/Mechatr	0	0	0	0	0	0	0	0
31	UO/ProdTech	0	0	0	0	0	0	0	0
	TOTAL	**4,442**	**3,020**	**5,726**	**6,382**	**6,175**	**5,162**	**8,640**	**7,067**
	TOTAL – VTT	**4,442**	**3,020**	**3,221**	**3,746**	**3,566**	**3,107**	**3,291**	**2,244**

Table 19. Funding from industry.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	100	100	182	125	127	366	245	0
2	TKK/CorrMater	0	0	88	159	163	144	182	153
3	TKK/MaterSci	27	61	70	156	105	97	32	115
4	TKK/Metallurgy	0	0	0	0	0	0	0	280
5	TKK/ProcHeat	110	93	74	64	89	17	71	111
6	TKK/MaterProc	212	245	374	433	495	421	355	476
7	TKK/CombEng	0	0	291	355	183	45	144	142
8	TKK/Aerodyn	70	90	72	51	135	73	119	230
9	TKK/Automotive	93	101	24	165	188	422	201	0
10	TKK/EngMater	207	241	126	250	244	450	428	420
11	TKK/Foundry	80	80	60	54	72	101	40	60
12	TKK/Lightweight	380	137	225	197	190	78	102	191
13	TKK/MachDes	600	457	512	776	663	994	998	1,336
14	TKK/MechMater	93	101	133	111	85	37	58	386
15	TKK/ProdEng	120	120	90	81	109	152	59	90
16	TKK/Ship	276	235	337	104	241	315	343	301
17	LUT/MechatrFatig	170	200	212	242	225	190	204	260
18	LUT/ProdEng	500	520	550	385	670	818	1,128	1,160
19	LUT/WoodTech	0	0	0	150	137	466	266	642
20	TUT/HydrAutom	157	290	220	437	366	247	573	529
21	TUT/MechDes	270	437	390	744	808	437	590	615
22	TUT/MaterSci	1,117	806	1,223	1,172	1,168	1,757	1,784	0
23	TUT/ProdEng	263	341	325	197	292	360	217	456
24	TUT/SafetyEng	55	20	32	35	13	6	4	16
25	VTT/IndSys	0	0	7,255	7,235	7,685	7,954	9,039	9,603
26	UO/EngMech	20	30	37	59	67	17	15	10
27	UO/Metallurgy	341	299	460	791	727	681	629	595
28	UO/MachDes	2	3	26	12	21	5	61	13
29	UO/MaterEng	435	465	515	667	667	409	350	438
30	UO/Mechatr	1	1	16	3	15	18	65	42
31	UO/ProdTech	4	18	53	10	11	39	35	14
	TOTAL	**5,703**	**5,491**	**13,972**	**15,220**	**15,961**	**17,116**	**18,337**	**18,684**
	TOTAL – VTT	**5,703**	**5,491**	**6,717**	**7,985**	**8,276**	**9,162**	**9,298**	**9,081**

Table 20. EU funding.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	250	200	52	186	222	18	73	0
2	TKK/CorrMater	0	0	0	0	8	44	46	42
3	TKK/MaterSci	0	0	0	0	0	0	0	6
4	TKK/Metallurgy	0	0	0	0	0	0	0	160
5	TKK/ProcHeat	16	78	93	69	12	0	0	0
6	TKK/MaterProc	164	87	126	122	146	154	167	170
7	TKK/CombEng	0	0	0	0	151	285	384	110
8	TKK/Aerodyn	80	90	86	100	118	81	49	39
9	TKK/Automotive	114	78	209	175	209	128	73	0
10	TKK/EngMater	0	162	172	166	131	47	39	56
11	TKK/Foundry	0	0	23	22	21	0	0	0
12	TKK/Lightweight	0	0	0	0	0	46	67	127
13	TKK/MachDes	0	0	0	15	54	64	81	90
14	TKK/MechMater	114	78	49	117	13	21	5	9
15	TKK/ProdEng	0	0	34	32	32	0	0	0
16	TKK/Ship	111	158	238	430	366	346	250	133
17	LUT/MechatrFatig	60	100	120	90	90	90	50	400
18	LUT/ProdEng	0	0	120	62	436	438	381	245
19	LUT/WoodTech	0	0	0	0	0	80	110	280
20	TUT/HydrAutom	0	0	0	0	0	93	100	299
21	TUT/MechDes	0	13	25	63	4	29	57	117
22	TUT/MaterSci	39	215	325	333	178	277	343	0
23	TUT/ProdEng	130	41	14	48	56	116	225	750
24	TUT/SafetyEng	26	0	0	0	0	0	0	0
25	VTT/IndSys	0	0	1,072	885	1,980	1,746	2,381	1,491
26	UO/EngMech	4	52	0	0	0	0	0	0
27	UO/Metallurgy	0	0	0	0	0	0	0	30
28	UO/MachDes	0	5	18	0	0	0	0	119
29	UO/MaterEng	64	64	64	100	100	126	217	274
30	UO/Mechatr	0	0	0	0	0	0	0	0
31	UO/ProdTech	0	0	11	0	0	0	0	0
	TOTAL	**1,172**	**1,421**	**2,851**	**3,015**	**4,327**	**4,229**	**5,098**	**4,947**
	TOTAL – VTT	**1,172**	**1,421**	**1,779**	**2,130**	**2,347**	**2,483**	**2,717**	**3,456**

Table 21. Total external funding.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	1,040	1,000	975	1,049	1,409	1,634	1,468	0
2	TKK/CorrMater	0	0	146	234	283	290	229	195
3	TKK/MaterSci	1,170	1,334	807	879	606	669	795	1,129
4	TKK/Metallurgy	0	0	0	0	0	0	0	910
5	TKK/ProcHeat	351	294	224	232	209	194	221	306
6	TKK/MaterProc	824	678	809	763	857	820	819	846
7	TKK/CombEng	0	0	1,205	997	1,156	722	745	491
8	TKK/Aerodyn	500	500	492	605	674	521	622	622
9	TKK/Automotive	264	227	352	503	541	660	419	0
10	TKK/EngMater	1,398	1,400	816	1,135	1,043	1,087	1,030	1,035
11	TKK/Foundry	160	160	175	134	158	118	52	88
12	TKK/Lightweight	658	271	532	531	488	491	421	512
13	TKK/MachDes	1,669	1,672	1,601	1,760	1,815	2,057	2,234	2,544
14	TKK/MechMater	268	279	245	275	161	95	167	592
15	TKK/ProdEng	240	240	262	201	237	178	77	132
16	TKK/Ship	1,149	1,128	1,132	830	904	903	962	955
17	LUT/MechatrFatig	715	821	1,023	1,273	1,515	1,432	1,229	1,922
18	LUT/ProdEng	1,300	1,220	1,568	1,145	1,833	1,994	2,157	2,125
19	LUT/WoodTech	0	0	80	280	387	612	588	1,032
20	TUT/HydrAutom	2,205	1,704	1,931	2,408	2,030	2,426	2,575	2,696
21	TUT/MechDes	1,049	913	901	1,176	1,537	1,231	1,514	1,696
22	TUT/MaterSci	4,660	4,619	4,727	4,297	4,136	4,771	5,208	0
23	TUT/ProdEng	1,560	1,641	1,882	1,365	1,567	1,529	1,782	3,091
24	TUT/SafetyEng	490	254	246	315	258	223	285	193
25	VTT/IndSys	0	0	14,844	14,657	16,601	15,469	21,133	21,561
26	UO/EngMech	279	256	210	158	116	75	71	22
27	UO/Metallurgy	1,118	982	880	1,141	1,142	1,252	1,065	971
28	UO/MachDes	50	61	67	14	129	36	80	371
29	UO/MaterEng	933	920	737	901	937	726	812	995
30	UO/Mechatr	61	87	151	190	179	262	244	314
31	UO/ProdTech	103	66	197	107	209	159	74	63
	TOTAL	**24,214**	**22,727**	**39,217**	**39,555**	**43,117**	**42,636**	**49,078**	**47,409**
	TOTAL – VTT	**24,214**	**22,727**	**24,373**	**24,898**	**26,516**	**27,167**	**27,945**	**25,848**

Table 22. Total funding.

	k€	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	1,640	1,650	1,639	1,713	2,159	2,365	2,331	0
2	TKK/CorrMater	0	0	455	560	628	673	635	532
3	TKK/MaterSci	1,739	1,925	1,250	1,518	1,392	1,408	1,576	1,835
4	TKK/Metallurgy	0	0	0	0	0	0	0	1,460
5	TKK/ProcHeat	822	714	547	610	600	733	628	706
6	TKK/MaterProc	1,067	919	1,070	1,042	1,165	1,091	1,094	1,166
7	TKK/CombEng	0	0	1,542	1,364	1,645	1,096	1,140	896
8	TKK/Aerodyn	880	880	872	1,034	1,110	933	1,020	1,029
9	TKK/Automotive	564	575	685	828	937	1,015	796	0
10	TKK/EngMater	2,085	2,054	1,522	1,877	1,728	2,085	1,895	1,938
11	TKK/Foundry	476	476	491	466	474	430	357	392
12	TKK/Lightweight	1,048	714	956	1,088	1,023	1,025	866	899
13	TKK/MachDes	2,867	2,936	3,009	3,091	3,145	3,536	3,562	3,930
14	TKK/MechMater	835	884	940	929	984	888	940	1,357
15	TKK/ProdEng	714	714	736	699	711	646	536	588
16	TKK/Ship	2,295	2,280	2,210	2,312	2,358	2,328	2,474	2,590
17	LUT/MechatrFatig	1,245	1,364	1,644	1,833	2,163	2,039	1,927	2,406
18	LUT/ProdEng	1,920	1,825	2,170	1,671	2,339	2,457	2,564	2,560
19	LUT/WoodTech	0	0	223	459	557	755	800	1,200
20	TUT/HydrAutom	4,647	4,169	4,341	4,682	5,017	5,375	5,059	5,495
21	TUT/MechDes	2,878	2,868	2,824	3,144	3,773	3,181	3,205	3,924
22	TUT/MaterSci	6,278	6,212	6,584	6,251	6,125	7,054	7,456	0
23	TUT/ProdEng	2,862	3,253	3,197	2,644	3,023	2,991	3,026	5,122
24	TUT/SafetyEng	965	649	715	823	849	809	845	876
25	VTT/IndSys	0	0	22,058	21,175	23,131	22,968	29,156	30,309
26	UO/EngMech	680	675	726	641	647	605	531	492
27	UO/Metallurgy	1,368	1,272	1,189	1,433	1,461	1,582	1,389	1,235
28	UO/MachDes	396	532	621	583	649	527	536	671
29	UO/MaterEng	1,484	1,655	1,430	1,611	1,632	1,347	1,443	1,340
30	UO/Mechatr	371	490	566	658	628	710	688	679
31	UO/ProdTech	524	309	474	408	569	498	405	410
	TOTAL	**42,650**	**41,994**	**66,686**	**67,147**	**72,622**	**73,150**	**78,880**	**76,037**
	TOTAL – VTT	**42,650**	**41,994**	**44,628**	**45,972**	**49,491**	**50,182**	**49,724**	**45,728**

Table 23. Publications in refereed journals and proceedings.

		Articles in refereed journals								Articles in refereed scientific volumes and proceedings							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	2	3	1	3	3	2	2	3	18	16	10	16	18	28	18	17
2	TKK/CorrMater	4	2	0	0	0	1	1	0	3	2	2	1	2	4	1	4
3	TKK/MaterSci	2	9	4	20	14	7	23	12	2	8	7	1	6	7	7	1
4	TKK/Metallurgy	4	4	4	4	4	4	4	4	9	9	9	9	9	9	9	9
5	TKK/ProcHeat	2	0	0	0	1	1	1	1	2	2	4	2	2	2	1	2
6	TKK/MaterProc	4	8	6	5	5	6	11	8	7	16	18	4	1	14	5	4
7	TKK/CombEng	0	1	2	0	1	1	0	0	1	0	2	3	2	2	1	3
8	TKK/Aerodyn	1	1	2	0	0	1	1	1	4	4	4	7	4	5	7	4
9	TKK/Automotive	1	1	0	0	0	2	0	1	4	4	3	2	7	3	8	5
10	TKK/EngMater	9	7	1	6	9	4	7	8	22	17	17	21	19	7	7	9
11	TKK/Foundry	0	0	1	1	1	0	1	0	2	2	4	6	3	1	2	2
12	TKK/Lightweight	0	0	0	0	1	0	0	0	0	1	2	0	5	3	3	2
13	TKK/MachDes	4	6	12	6	4	6	3	5	11	19	26	32	19	21	22	27
14	TKK/MechMater	1	2	2	3	4	1	0	0	7	10	3	6	6	7	4	6
15	TKK/ProdEng	1	1	2	2	1	0	1	0	3	3	5	8	4	2	4	2
16	TKK/Ship	2	3	1	1	4	1	4	5	7	13	6	14	12	10	5	10
17	LUT/MechatrFatig	0	5	4	14	7	8	16	14	12	37	34	32	21	27	26	23
18	LUT/ProdEng	3	11	5	13	6	12	15	0	56	26	20	30	18	38	21	0
19	LUT/WoodTech	0	0	3	0	2	0	3	3	6	2	4	3	4	0	2	0
20	TUT/HydrAutom	3	2	12	13	2	2	7	3	36	40	53	39	21	43	16	41
21	TUT/MechDes	7	8	7	7	9	5	6	9	39	43	40	33	36	38	45	35
22	TUT/MaterSci	14	21	29	12	19	10	14	0	17	32	60	22	12	36	18	0
23	TUT/ProdEng	0	1	0	1	2	6	8	5	14	3	2	3	1	11	5	0
24	TUT/SafetyEng	4	4	9	2	0	2	3	2	0	0	0	0	0	0	0	0
25	VTT/IndSys	0	0	3	24	23	12	32	29	0	0	48	68	52	58	46	44
26	UO/EngMech	0	2	4	4	3	2	2	2	9	4	3	4	2	2	4	3
27	UO/Metallurgy	0	4	10	4	6	4	4	4	6	1	5	10	6	4	4	4
28	UO/MachDes	0	0	0	0	0	0	0	0	2	7	6	5	3	4	0	2
29	UO/MaterEng	3	5	4	2	8	8	2	8	14	18	3	8	13	5	6	9
30	UO/Mechatr	2	1	4	2	1	5	1	6	4	11	5	13	12	5	11	11
31	UO/ProdTech	0	0	0	0	0	0	0	1	2	1	6	1	1	1	1	9
	TOTAL	**73**	**112**	**132**	**149**	**140**	**113**	**172**	**134**	**319**	**350**	**411**	**403**	**321**	**397**	**309**	**288**

Table 24. Education statistics.

		Master's degrees								Doctoral degrees							
		2000	2001	2002	2003	2004	2005	2006	2007	2000	2001	2002	2003	2004	2005	2006	2007
1	TKK/AutomTech	7	10	9	6	11	17	15	19	1	1	1	1	1	1	1	2
2	TKK/CorrMater	1	1	1	1	2	5	3	2	0	1	0	0	1	0	0	0
3	TKK/MaterSci	3	6	5	4	8	4	2	9	0	0	1	1	0	3	2	1
4	TKK/Metallurgy	0	0	0	0	0	0	7	6	1	1	1	1	1	1	1	2
5	TKK/ProcHeat	2	3	4	4	5	4	5	4	0	1	0	0	0	0	0	0
6	TKK/MaterProc	2	3	3	2	1	4	2	2	1	0	0	0	1	1	1	1
7	TKK/CombEng	0	0	1	1	1	5	3	7	0	0	0	1	0	0	0	1
8	TKK/Aerodyn	3	4	5	4	2	3	4	3	2	0	0	0	1	0	0	1
9	TKK/Automotive	0	0	12	6	4	10	8	0	0	0	0	0	0	0	0	0
10	TKK/EngMater	2	4	4	4	2	4	3	7	1	2	0	0	2	1	1	1
11	TKK/Foundry	0	2	3	1	2	0	6	3	0	0	0	0	0	0	1	0
12	TKK/Lightweight	1	4	7	1	4	4	6	2	0	0	0	0	0	1	0	0
13	TKK/MachDes	40	29	40	25	41	40	47	46	1	1	1	0	1	3	2	0
14	TKK/MechMater	1	4	9	5	5	5	4	10	0	2	0	0	2	0	1	2
15	TKK/ProdEng	23	24	22	25	18	18	26	23	0	0	0	0	0	0	1	0
16	TKK/Ship	14	13	18	13	11	10	14	10	0	0	0	1	0	1	1	2
17	LUT/MechatrFatig	16	15	28	19	15	18	19	15	0	1	3	3	2	2	5	2
18	LUT/ProdEng	12	10	8	15	23	22	23	41	1	1	0	1	0	0	0	1
19	LUT/WoodTech	7	6	8	7	8	12	4	4	0	0	0	0	0	0	0	0
20	TUT/HydrAutom	26	21	15	11	11	15	27	16	2	4	5	0	2	0	0	4
21	TUT/MechDes	27	31	27	37	20	17	21	31	3	2	2	4	1	1	1	2
22	TUT/MaterSci	36	26	29	26	36	29	34	0	1	3	4	6	4	2	1	2
23	TUT/ProdEng	47	41	44	35	46	56	63	82	1	1	1	0	2	2	5	5
24	TUT/SafetyEng	12	7	9	9	12	14	9	13	1	3	1	1	1	0	0	3
25	VTT/IndSys	0	0	4	3	0	1	0	5	0	0	2	1	4	4	3	1
26	UO/EngMech	2	4	3	4	3	2	4	4	1	0	0	0	1	0	1	0
27	UO/Metallurgy	7	3	9	12	10	8	7	8	0	0	0	0	2	0	1	0
28	UO/MachDes	10	13	16	18	12	12	12	30	0	0	1	0	0	0	1	0
29	UO/MaterEng	7	4	3	1	3	4	3	5	0	1	0	1	1	0	1	1
30	UO/Mechatr	3	8	11	6	3	1	3	6	0	0	0	1	1	0	2	0
31	UO/ProdTech	15	13	11	8	14	13	14	17	0	0	0	0	1	0	0	0
	TOTAL	**326**	**309**	**368**	**313**	**333**	**357**	**398**	**430**	**17**	**25**	**23**	**23**	**32**	**23**	**33**	**34**

B. Members of evaluation panel

Professor Monika Ivantysynova, Purdue University, West Lafayette, USA

Panel Chair Monika Ivantysynova is Professor of Agricultural and Biological Engineering and Mechanical Engineering at Purdue University since 2004. She is the Director of the MAHA Fluid Power Lab at the university. She got her PhD from the Slovak Technical University of Bratislava in 1983 and returned in 1991 to academia after working in industry. In 1996 she received a professorship in fluid power and control at the University of Duisburg, Germany, and in 1999 became Professor of Mechatronic Systems at the Technical University of Hamburg-Harburg, Germany, where she established a comprehensive fluid power research laboratory. Her research centres on the optimisation of hydraulic component design, advanced system solutions, motion control with electro-hydraulic actuation and the development of design algorithms. Her current research also includes the development of new energy-saving hydraulic actuators for heavy duty manipulators and robots as well as new actuator solutions and controls for aircraft system applications. Besides her book "Hydrostatic Pumps and Motors: Design and Computational Methods", published both in German and in English, she has published about 75 papers in technical journals and at international conferences. Professor Invantysynova is editor-in-chief of the International Journal of Fluid Power and an initiator and a scientific board member of the first virtual network of fluid power research and education centres worldwide, that is, Fluid Power Net International (FPNI).

Professor Adib Becker, University of Nottingham, Nottingham, UK

Adib Becker is Professor of Mechanical Engineering at the School of Mechanical, Materials and Manufacturing Engineering of the University of Nottingham, and Head of the Structural Integrity and Dynamics Research Group. He joined the university in 1990 and was appointed to a chair in 2001. He obtained his BSc in 1979 and his PhD in 1983 in mechanical engineering from Imperial College, London. He returned to Imperial College as a Lecturer in 1986, before moving to Nottingham. He is a member of several professional committees, a member of the editorial board of the International Journal of Engineering Simulation and has chaired several international conferences. Professor Becker has performed research in computational mechanics and stress analysis, including finite element advanced simulations, boundary element techniques, high-temperature and creep applications, analysis of welds, non-linear numerical procedures, contact mechanics and manufacturing simulations. He has published more than 190 publications in the open literature, including 80 journal papers, and is the author of three textbooks on finite element and boundary element methods.

Professor Rajamohan Ganesan, Concordia University, Montreal, Canada

Dr Rajamohan Ganesan was promoted to Professor of the Department of Mechanical and Industrial Engineering at Concordia University, Montreal, in 2007. He joined the Department of Mechanical and Industrial Engineering as Assistant Professor in 1997, became Associate Professor in 2000 and was appointed to a Concordia University Research Chair in 2001. He has been a faculty member of Concordia Centre for Composites (CONCOM) and Quebec Centre for Research on Polymers and Composites (CREPEC). Dr Ganesan obtained his PhD in Engineering in 1991 from Indian Institute of Science (IISc). He has been working in the areas of stress analysis, vibrations, composite materials and structures, stochastic mechanics and finite element method. He has published more than 60 papers in a spectrum of international journals and more than 70 papers in international conferences. He has made significant contributions to composite materials and structures, in particular to applications of stochastic mechanics.

Professor Petter Krus, Linköping University, Linköping, Sweden

Petter Krus is Professor in Machine Design at the Department of Management and Engineering, Linköping University, and Head of the Division of Machine Design. He got his PhD from Linköping University in 1988 and became Associate Professor in 1992 at the same division. In 2001, he was promoted to professor and was also appointed Professor of Machine Design. His research is in the field of design optimisation, modelling and simulation, requirement management and concept development. Application areas are primarily aircraft, road vehicles and construction equipments. Krus has also been active in the area of hydraulic power systems, specialising in system dynamics and control systems. He has published more than 100 papers in international journals and conferences.

Professor Lin Li, University of Manchester, Manchester, UK

Professor Lin Li holds a chair in laser engineering and has since 2000 been Director of the Laser Processing Research Centre at the University of Manchester, UK. He obtained a BSc degree in control engineering from China in 1982 and a PhD degree in laser engineering from Imperial College, London, in 1989. He worked for six years at Liverpool University as Researcher Associate before joining the University of Manchester Institute of Science and Technology in 1994 as a faculty member (Lecturer), and started setting up laser processing research activity there. In 2000 he was promoted to a full professor. Professor Li now heads the manufacturing research group at the University of Manchester. He is the author and co-author of more than 400 publications including 40 patents and more than 200 journal papers. Between 2000 and 2008 his research group has successfully completed 17 PhD degrees under his supervision and collaborated with more than 50 companies. He has been awarded a Fellowship of the Institute of Engineering and Technology and a Fellowship of the Laser Institute of America. He serves on the editorial board of the Optics and Laser Technology and Association of Industrial Laser Users (AILU) executive committee. He has been on the scientific committees of a large number of international conferences. He is Co-director of the Northwest Laser Engineering Consortium in the UK and Director of the Rolls-Royce Laser Technology Partnership. His research interests include laser cutting, welding, drilling, surface engineering, micro/nano-fabrication and additive/rapid manufacturing.

Professor Jan-Gunnar Persson, Royal Institute of Technology, Stockholm, Sweden

Jan-Gunnar Persson is Professor of Machine Design at the Department of Machine Design, Royal Institute of Technology (KTH), since 1988. After graduating from KTH he worked in industry during 1967–1987, gathering wide experience in mechanical engineering and computer aided design, as well as technology development, especially in the field of fluid machinery. After receiving his Licentiate of Engineering he returned to KTH as Associate Professor in 1987, before moving on to his present position. His research topics include product development process and design methodology, methods for modelling, performance simulation and optimisation during conceptual design and sustainability. Areas of application include industrial robots, mechanisms, manipulators, energy conversion systems, automotive fuel cells and fluid machinery. Professor Persson is a member of several national and international committees and he has been member of various boards within KTH. He has published 75 papers on international forums and is co-author of a comprehensive textbook in Swedish on product development.

Professor Panos Tsakiropoulos, University of Sheffield, Sheffield, UK

Panos Tsakiropoulos is Professor of Metallurgy and POSCO Chair in Iron and Steel Technology at the Department of Engineering Materials of the University of Sheffield, since 2006, and Director of IMMPETUS (Institute for Microstructural and Mechanical Process Engineering: University of Sheffield) since 2008. He was awarded his PhD from the University of Sheffield in 1979 and was part of the faculty before moving to the University of Surrey in 1986, where he became Professor of Metallurgy in 1996. His research interests are in the design and development of ferrous and non-ferrous alloys and composites for the energy, transport and aerospace industries and for biomedical applications via process-microstructure-property studies. His research also covers materials processing under equilibrium and non-equilibrium conditions, as part of the alloy development. His research has resulted in eight patents. Professor Tsakiropoulos is a member of several national and international committees and has given numerous conference lectures and 145 presentations on international forums. He has published about 260 refereed papers.

C. Terms of Reference for the evaluation panel

1 Objective of the evaluation

The objective is to evaluate mechanical engineering research in Finland during the period 2000–2007. The evaluation includes research units at universities and in research institutes. The evaluation is based on the self-assessment reports of the research units and the site visits by the evaluation panel. The panel is asked to look at the research from three different viewpoints: the field as a whole, the different subfields and at unit level. The evaluation report should present a critical assessment of the quality and relevance of research in mechanical engineering science in Finland. The quality, innovativeness and efficiency of the research should be compared with international standards. The panel is asked to provide recommendations for the future development of the research.

Additionally, the panel may consider the following items:

- Strengths, weaknesses, opportunities and threats of the research
- Impact on science and on society in general
- Resources (facilities, personnel, economic resources) and infrastructures
- Research network and collaborations (national, international and multidisciplinary)
- Education and career policies
- Any other issue the panel considers important

2 Evaluation report and confidentiality

The results of the evaluation are collected to a report published by the Academy of Finland. Panellists will divide the work of writing the report amongst each other. The main responsibility for collecting and compiling text from the panellists is placed on the chair of the evaluation panel, who will be assisted by the coordinator of the evaluation. The Academy of Finland will provide editorial assistance for writing the report. The report will contain statements describing the research from three viewpoints: the field as a whole, the different subfields and at unit level. The report will also contain recommendations by the panel.

Panel members will be provided certain detailed information that is intended for evaluation purposes only. Panel members are asked to keep such information, knowledge, documents or other matters confidential. This does not apply to information that is available from public sources or clearly marked as non-confidential. The extent to which detailed data on the units can be used in the final report must be agreed between the panel, the Academy of Finland and the coordinator. Any possible conflicts of interests are also determined and handled based on discussions between the panellists, the Academy of Finland and the coordinator.

3 Organisation

The Steering Group appointed by the Academy of Finland Research Council for Natural Sciences and Engineering will oversee the evaluation process. The evaluation panel appointed by the President of the Academy will write the report. The panel will be aided by the coordinator and by the responsible official of the Academy. The report is published by the Academy.

D. Self-assessment form

1. GENERAL INFORMATION

Unit	
Address	
Phone	
Website	
Department or equivalent	
Head of the Department	
Phone	
Email	
Contact person for the Evaluation	
Phone	
Email	

1.1 Percentage of mechanical engineering research of the research carried out in the unit

1.2 Unit's research profile within mechanical engineering (give estimate of percentage)

Research field	(%)
Machine automation	
Machine design	
Manufacturing and tooling technologies	
Material technology*	
Production engineering	
Vehicle technology	
Other (specify)	

*For material technology, include research that supports mechanical engineering. For example, metallurgy is included.

2. PERSONNEL

2.1 Personnel in 2000–2007 (person-months/FTEs)

	2000	2001	2002	2003	2004	2004	2005	2007	Total
Professors									
Other senior researchers									
Postdoctoral researchers									
Postgraduate students									
Other academic staff									
Visiting researchers and visiting research students									
Total active research staff									
Administrative personnel									
Technical personnel									

2.2 Senior and postdoctoral researchers. If the researcher got his/her PhD from some other unit, please indicate where.

Name	Title	Period	PhD from

3. FUNDING

3.1 The unit's core and external funding

Source of Funding		2000	2001	2002	2003	2004	2005	2006	Total
Core funding	Budget funding								
	Other								
	Total core								
External funding	Academy of Finland								
	Tekes								
	Other public sources								
	Industry								
	Private foundations								
	EU								
	Other foreign organisations								
	Total external								
Total									
Notes (if applicable)									

4. RESEARCH STRATEGY

4.1 Describe the unit's research and strategy (max. 6 pages)

4.2 Describe the administrative and educational load (max ½ page)

5. RESEARCH OUTPUT

5.1 Publications

5.1.1 Number of scientific publications and other outputs 2000–2007

Type of output	2000	2001	2002	2003	2004	2005	2006	2007
1. Articles in refereed scientific journals								
2. Articles in refereed scientific edited volumes and conference proceedings								
3. Monographs published (excl. theses)								
4. Text books and other research-related publications								
5. National patents								
6. International patents								
7. Other scientific publications								

5.1.2 List the 15 most important publications of the unit during 2000–2007

5.1.3 Copies of the unit's most important publications

(Append copies of the 15 most important publications)

5.2 Education

5.2.1 Number of students in 2000–2007

	2000	2001	2002	2003	2004	2005	2006	2007
Study towards Master's degree								
Completed Master's degree								
Avg. time to complete Master's degree								
Completed doctoral degree								

5.2.2 List of doctoral dissertations in 2000–2007 and the person's present employment

Name (surname, first name)	Year of birth	Gender	Topic of dissertation	Year of completing the degree	Time to complete the degree	Present employment (job description, organisation)

6. NATIONAL AND INTERNATIONAL COLLABORATION

6.1 National collaboration

Organisation	Type of collaboration	Period	Person-months	Field of science	Results

6.2 Visits abroad (min. duration of visit: one month)

Name	Target organisation	Country	Purpose of visit	Duration (months)

6.3 Visits to the unit (min. duration of visit: one month)

Name of visitor	Home organisation	Country	Purpose of visit	Duration (months)

6.4 Short but particularly important visits

Name of visitor	Home organisation	Country	Purpose of visit

6.5 Most important foreign collaborators

Name and organisation	Type of collaboration	Country	Period	Person-months	Field of science	Results

6.6 Describe the most important outcomes of the visits and collaboration contacts (max. 1 page)

6.7 Non-academic collaboration

Name and organisation	Type of collaboration	Country

7. OTHER SCIENTIFIC AND SOCIETAL ACTIVITIES

7.1 Invited presentations at scientific conferences

Name	Topic of presentation	Country

7.2 Memberships in editorial boards of scientific journals and standardisation bodies

Name	Journal	Period

7.3 Prizes awarded to researchers, honours and scientific positions of trust

Name	Prize, position etc.

7.4 Memberships in committees and scientific advisory boards of business companies, or other similar tasks not of primarily academic nature

Name	Tasks	Period

8. UNIT SELF-ASSESSMENT

8.1 SWOT – evaluation of the unit's scientific strengths, weaknesses, opportunities and threats (expertise, funding, facilities, organisation; max. 2 pages)

8.2 Evaluate the unit in relation to its leading scientific competitors (max. 1 page)

8.3 Societal impact of the unit's activities (max. 1 page)

8.4 Assess the academic and societal need for doctoral training within the unit's research fields and the unit's role in doctoral training (max. 1 page)

8.5 Assess the research infrastructure available (max. 1 page)

8.6 Evaluate the role of the funding by the Academy of Finland in promoting the scientific and societal impact of research (max. 1 page)

8.7 Evaluate the role of funding awarded by different funding organisations in promoting the scientific and societal impacts of research, excluding funding from the Academy of Finland (max. 1 page)

8.8 Describe how the doctoral students are funded. How does the source of funding affect the studies?

Instructions for submission form

1. General information

1.1 This evaluation covers research related to mechanical engineering. The research fields relevant in the evaluation are listed in Question 1.2. In your unit there may be many other fields of research represented, but we ask you to give the percentage that mechanical engineering stands for. **Question 1.2 and the remaining questions in this form concern only this part of your research.**

1.2 Subdivide your mechanical engineering research between the given research fields. The percentages should add up to 100. If there are more "Other" fields, you may add more lines.

2. Personnel

2.1 Indicate information on the personnel. Use months of full time equivalent work (a normal year including vacations is twelve months of full time equivalent work). If there is also other research in your unit, estimate the personnel resources allocated to mechanical engineering appropriately.

Postdoctoral researchers are counted as senior researchers from the fourth year after attaining the PhD degree. Postgraduate students employed by graduate schools are counted as well.

3. Funding

3.1 Core funding applies to the unit's budget funding and possible other funding for research awarded by the host organisation. The funding covers both the salary costs with social charges of the staff and the operational costs, which include consumption costs and investment costs for research activities.

Academy of Finland fellowships are counted using 1.33*(gross salary). If there is also other research in your unit, estimate the resources allocated to mechanical engineering appropriately.

4. Research strategy

4.1 This question surveys how the research carried out in the unit has impacted research in mechanical engineering and specifically in the fields of Table 1.2. Give a brief description of your unit and summarise its research in these fields. Indicate briefly how this research relates to other research done in your unit. Describe the orientation of scientific publishing, the most important research results and the role of multidisciplinarity or interdisciplinarity. In case the research is clearly divided into different fields of Table 1.2, you may treat each field separately, in which case you should also describe how the fields support each other.

Describe the unit's research programme for the next few years, the key research objectives as well as the means to achieve these objectives. What is the role of basic and applied research? Is there need for new knowledge and facilities; is the present level of funding sufficient for attaining the objectives laid down?

4.2 Describe how activities not related to research affect the time and other resources available for research.

5. Research output

5.1.1 You may include papers that have been accepted for publication before 2008.

5.1.2 Unlike table 5.1.1, the list may also include manuscripts published or approved for publication in 2008.

5.1.3 To ensure easy readability, do not make the font size smaller when copying publications. The copies of publications shall be two-sided.

5.2 Education

5.2.2 If at least half of the doctoral dissertation has been supervised and done at a research institute, the research institute can also list the doctoral dissertation as its own outcome. In this case, indicate also the university (in year of completion) where the doctoral dissertation has been presented for approval. In present employment, indicate the type of organisation (university, business company, research institute, state, municipality or other).

6. National and international collaboration

6.1 List the national collaboration partners of the unit. Collaborator refers to a person or research team with whom the cooperation has either generated or is expected to generate within the next three (3) years one of the outcomes indicated in item 5.1.1. Types of collaboration include joint projects and researcher mobility, for instance. In "Field of science", give the main field of the collaborator (physics, chemistry, computer science etc.). Briefly list the type of results (joint publication etc). The details of the most important results can be described in item 6.6.

6.2–6.4 List visits per year. List the visits of each year by country in alphabetical order. In item "Purpose of the visit" indicate clearly the objective of the visit.

6.5 List the most important foreign collaborators, as defined in item 6.1.

6.6 Describe here, for example, key joint publications, researcher training, adoption and use of new technologies or new approaches.

6.7 List here the unit's non-academic collaboration, for example industry contacts.

7. Other scientific and societal activities

7.1 Invited plenary talks and other invited talks

7.2–7.4 Give only the most important memberships and prizes

8. Unit self-assessment

Self-assessment is an important part of the evaluation. Please answer carefully.

8.1 and 8.2

In addition to strengths and weaknesses, it is also important to assess what the present strengths or developable strengths enable in future and what kinds of threats are related to the weaknesses.

8.3 Describe here how the unit's research activities and cooperation with other actors in society have promoted the activities of other societal actors, for example industry or small and medium-sized enterprises. Have there been spin-off companies formed based on the unit's work?

8.4 What kinds of prospects does a newly graduated doctor from the unit have?

8.5 Describe the use and availability of research infrastructures, for example laboratory equipment, both from the parent organisation and outside.

8.6 Describe how the funding awarded by the Academy of Finland has promoted the scientific and societal impact of the unit's activities. Scientific impact refers to the contribution of the research carried out by the unit to the development of the field. Societal impact refers to the ability of the research activities to promote values that are considered important in society.

8.7 Describe the contribution of the funding awarded by different funding organisations to the scientific and societal impacts.

8.8 How does the source of funding (internal, Academy of Finland, Tekes, industrial) affect the doctoral studies?

In 2007, the Academy of Finland appointed an international expert panel to evaluate mechanical engineering research in Finland. The objective was to evaluate the quality of mechanical engineering research and its subfields as compared to international standards.

The evaluation targets public research investment in the field and covers relevant research carried out at universities and research institutes during 2000-2007.

This report includes the results and recommendations of the evaluation by an international expert panel. The report also includes proposals for the future development of research in the field.

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