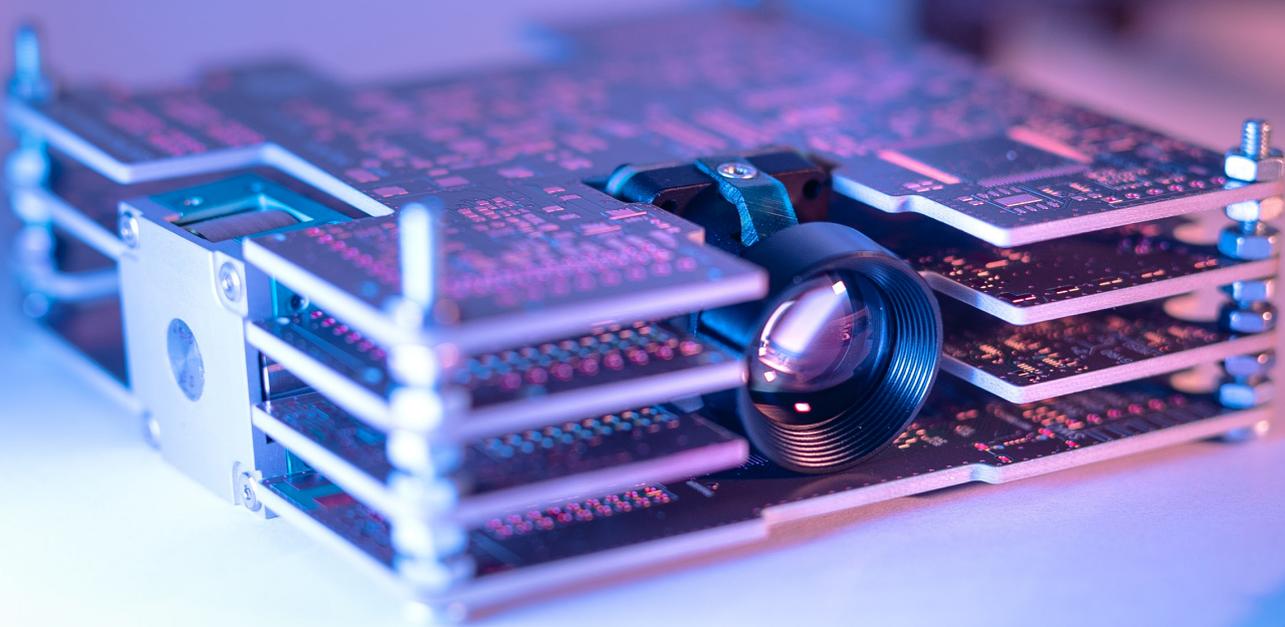


TARGETED EVALUATION
OF TALLINN UNIVERSITY
OF TECHNOLOGY
PROFESSORSHIPS
IN FIELDS OF NATURAL
SCIENCES AND
ENGINEERING AND
TECHNOLOGY



EVALUATION REPORT
8/2022



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Targeted evaluation of Tallinn University of Technology professorships in fields of Natural Sciences and Engineering and Technology

EVALUATION REPORT
8/2022

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1. Introduction

The objective of this report is to detail the outcomes of a targeted evaluation of the research work of eight professorships at Tallinn University of Technology within the fields of Engineering and Technology, and Natural Sciences. Each respective professorship has been evaluated in respect of their compliance to internationally recognized standards of research as well as their efficiency of use of activity support allocated to them. Their impact on the development and standard of their fields of study in comparison with the outcomes of the regular evaluation of 2017 was also considered and evaluated. The efficiency, impact, and standard were overall evaluated in terms of their output of scientific research, interaction between research and society, international cooperation, and sustainability of the field, incl. PhD studies and in respect of the educating of next generation researchers.

The professorships in the research areas of public interest of Estonia were founded in accordance the university's Council decision No. 147 from 16th December 2014, based on the Tallinn University of Technology Act and the administrative agreement between the Ministry of Education and Research and Tallinn University of Technology (No. 1.1-6.2/19/93). The professorships were formed in the public interest of Estonia to engage in teaching, research and development of engineering and thus to ensure the offspring of engineers and engineering scientists in Estonia, contributing to the fulfilment of the university's development plan 2015–2020 which strived for:

- 1) strengthening research teams vital for the economy and society
- 2) international outreach and multifaceted, international research cooperation
- 3) strengthening cooperation with technology-intensive enterprises and the public sector
- 4) stressing the importance of evidence-based teaching.

Based on the Minister's Directive No. 1.1 2/21/224, this targeted evaluation was undertaken in research and doctoral studies at Tallinn University of Technology (hereinafter TalTech) in the fields of Natural Sciences and Engineering and Technology, within the following professorships:

- Professorship of Structural Engineering (Alar Just)
- Professorship of Electrical Engineering (Lauri Kütt)
- Professorship of Information Society Technologies (Dirk Draheim)
- Professorship of Chemical Engineering (Oliver Järvik)
- Professorship of Metals Engineering (Jakob Kübarsepp)
- Professorship of Woodworking (Jaan Kers)
- Professorship of Oil Shale Technology (Alar Konist)
- Professorship of Production Engineering (Tauno Otto)



To obtain the materials necessary for the evaluation of added value and the quality of research at the international level, the following steps were made:

1. Six meetings of the evaluation panel for discussion, division of tasks, and writing up the report.
2. Briefing by representatives of Estonian Research: R&D system and policy by Nensi Meidla, R&D analyst, Estonian Research Council.
3. Virtual site visits were carried out over two days. A virtual meeting with the administration was followed by more specialised presentations by the professorships and their respective teams, including interviews with the teams, pre-recorded virtual tours of the professorships' infrastructure and meetings with doctoral students.
4. Further revision and quantitative justification were performed in August and September 2022 based on the feedback from the Steering Committee and Professors.

The meeting with the administration involved the following officers: Maarja Kruusmaa, Vice Rector for Research; Gert Jervan, Dean of School of Information Technologies; Argo Rosin, Vice-Dean for Research of School of Engineering; Maia-Liisa Anton, Head of Research Administration Office.

The following steps were made to obtain an informed opinion about the eight professorships:

- Pre-reading the materials provided by the professors
- Identifying missing information that would establish added value
- Establishing the standards for comparison
- Requesting additional material from the University and ETAG
- Online searches for details of publications, outputs and media coverage concerning the professorships
- Reading the findings of online media coverage
- Executing ways and methods at our disposal and within our expertise to obtain additional information
- Discussing all information to compile and revise the final report

As specified by "*Assessment criteria for targeted evaluation of professorships of TalTech*" the following scale was employed in evaluating the level of the research, societal, state-oriented, and professional activities and doctoral studies:

- Excellent: The majority of the submitted works are at a high international level and virtually all others at a good international level.
- Good: The majority of the submitted works are at least at a good international level and virtually all others at a fair international level.
- Satisfactory: The majority of the submitted works are at least at a fair international level.
- Unsatisfactory: Majority of the submitted works do not correspond to a fair international level.



The following scale was used to determine the international level:

- “High international level” relates to work which is apt to arouse serious interest within international academic communities and which in principle, if offered, could be published by the leading international publishers or in the leading international journals with the most rigorous editorial standard.
- “Good international level” means work which is of undisputed relevance for international academic communities and which could be published by well-known international publishers or in well-known international journals.
- “Fair international level” means work which is of possible relevance for international academic communities and which has been published abroad or by well-known national publishers or in well-known national journals

2. Evaluation Procedure

2.1. Evaluation Period

The evaluation was scheduled for spring 2022. Written documentation was provided by the Estonian Research Council (Eesti Teadusagentuur, ETAG) on 31 March. Virtual site visits of TalTech took place via MS Teams, on 26 and 27 April. The draft version of the evaluation panel's report was submitted on the 24th of May. The final version of the report was submitted on the 27th of May 2022. The revised version, which addresses comments of ETAG, the Steering Committee, and the TalTech was handed in on the 27th September 2022.

2.2. Evaluation Procedure

As outlined previously, in line with the detailed rules of procedure for performing the targeted evaluation of professorships of TalTech, the Panel assessed the compliance of the professorships research to internationally recognized levels and their effectiveness in their use of operating support allocated to them. In addition, their impact on the development and level of engineering and technology and natural sciences was compared to the results of the 2017 regular evaluation. Performance, impact, and level was assessed in terms of the outputs of scientific research, the interaction between research and society, international cooperation, and the sustainability of the field, including doctoral studies.

Concerning the professorships of the public interest of Estonia, the Panel was asked to:

- I. evaluate the quality of research and development in Estonia within the framework of TalTech professorships compared to the international level
- II. evaluate the societal and professional activities undertaken in the field by TalTech professorships
- II. assess the organisation of research in TalTech
- IV. assess the quality and relevance of the doctoral studies carried out by the professorships

Furthermore, the Panel was tasked to make recommendations concerning the further development and financing of research and development activities and doctoral studies within the field and the performance of necessary changes in Estonia.

3. Assessment

Key statistics for the professorships over 5 years alongside indications for the award of **preliminary** grades are shown in the table below. Note that **final** grades may also take into account other factors and indicators.

	Just	Kütt	Draheim	Järvik	Kübar-sepp	Kers	Konist	Otto
RESEARCH QUALITY								
Publications in Web of Science or Scopus (journals/conferences)	15(6)	23 (43)	23 (104)	34(6)	109(60)	23(5)	28(7)	54(57)
	Good	Excellent	Excellent	Good	Excellent	Good	Good	Excellent
PUBLIC OUTREACH								
Estonian public sector funding/private sector funding (EUR)	380k /50k	1.4m /260k	4.2m /800k	530k /647k	3.3m /552k	2.8m /337k	1.4m /762k	5m /356k
	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
INTERNATIONAL LEVEL								
Impact (citations/h-index)	560/10	870/16	2440/26	1830/22	1160/17	830/13	790/17	850/16
EU Funding (EUR)	150k	40k	1.8m	-	11k	243k	-	1.6m
	High	Good	High	Good	Good	High	Good	High
SUPERVISION								
PhD-students (total/defended)	8(3)	5(4)	28(7)	7(3)	26(14)	4(3)	6(2)	27(14)
	Good	Good	Excellent	Good	Excellent	Good	Good	Excellent

3.1. Assessments of Individual Professorships

3.1.1. Professorship of Structural Engineering (Alar Just)

3.1.1.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: *Excellent ***Good** *Satisfactory *Unsatisfactory

Public Outreach: *Excellent ***Good** *Satisfactory *Unsatisfactory

International level: ***High** *Good *Fair

The construction industry provides an essential proportion of the GDP of Estonia. The Ministry of Education and Science has laid the institutional responsibility for civil engineering education in Estonia on TalTech, with the Professorship of Structural Engineering be partly responsible. The Professorship was filled in 2018 and coordinates R&D and teaching activities in structural engineering, specializing in timber structures. The research group is responsible for teaching and research in the field of timber, steel, concrete, masonry structures, geotechnics and foundations. Fire safety is one of the primary challenges for timber structures and as such, research is particularly focused on fire safety for timber structures, for which the group is well qualified.

Over the course of five years the research group has consisted of 14 members, of which 7 have a PhD and 4 are PhD students. Additionally, there are 2 PhD students from other universities (ETH Zürich and TU Munich) associated with the research group.

3.1.1.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

The group has significant domestic teaching, research and development collaborations with different Estonian organizations and also with construction enterprises. They provide their expertise in industrial research, consultancy and development projects to fulfil the needs of Estonian construction and structural engineering companies and have been highly evaluated as lecturers in continuous education courses for professionals. The research group is responsible for supporting the Estonian Standardization Centre in implementing the new generation of Eurocodes in Estonia and the laboratory serves external companies for the testing of load-bearing structures. The group has contributed to the development of infrastructure required for research and teaching and cooperation with both enterprises and the public sector. The interaction and cooperation between the research group and society is versatile and very active.

Although the EU funding is not at a high level, the research group has an impressive list of international partners, universities and research institutes, including: ETH Zurich, TU Munich, Rise Research Institute of Sweden, MPA Technical University Stuttgart, Technical University Braunschweig. The group has its own laboratory and all fire testing for cooperation partners is undertaken with the help of staff and PhD students. The group also has a close cooperation with fire laboratories at RISE and at ETH Zürich. The above justifies our assessment in the criteria as high.



Overall, the group appears to have a strong and established international cooperation at different levels with re-known units. As such, it can be considered that it contributes to the development of fire safety of timber structures both nationally and internationally.

3.1.1.3. PHD SUPERVISION

Doctoral Studies: *Excellent ***Good** *Satisfactory *Unsatisfactory

Doctoral studies are related to the applied research of the group and each PhD student has a dedicated supervisor. Students can meet and discuss with the supervisors whenever required, where the group also arranges regular meetings between PhD students, including the external partners, to exchange knowledge. Students undergo attestation once per academic year. The PhD students do not have organized cooperation or common meetings with other students in the fields of engineering and technology, and primarily work together as a small group. The PhD students usually cooperate in their research with other research institutes and universities in Europe. This is significant for them, but it's also challenging for undertaking supervision. However, overall, the present system seems to be working well.

Doctoral studies of the research group are heavily related to standardization. Input is given to the revision of European design standards. For the development of the fire aspects of Eurocode 5, the research group has one of the leading positions in Europe.

3.1.1.4. RECOMMENDATIONS

It is recommended that the research outputs of the group should be published in more well-known scientific journals to achieve higher quality and recognition.

The supervision of PhD students should be more formalized. The students and supervisors should meet formally more regularly to discuss the progress of their doctoral studies, which is challenging at present because of the level of international collaborations. However, this should not be at the sacrifice of the current informal supervision, which is considered by the panel to be beneficial due to the existing meetings with collaboration partners. The integration of PhD students with other PhD students in the fields of engineering and technology should also be encouraged.

The level of external research funding is quite low and thus more efforts should be invested in securing R&D projects financed by industry and the European Union. The potential for applying for further joint funding with international partners and from international sources should be explored.



3.1.2. Professorship of Electrical Engineering (Lauri Kütt)

3.1.2.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: ***Excellent** *Good *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: *High ***Good** *Fair

The Professorship of Electrical Engineering aims to provide an impact through studying the principles of electrical engineering. Overall, it is considered that the fundamental research within the Professorship of Electrical Engineering is excellent, in terms of quality and contribution to science. An impressive infrastructure has been developed, for example, with The Centre of Measurement of Electrical Technologies which, since 2021, is an accredited lab for measurement services of electromagnetic fields in the frequency range 10 Hz – 3 GHz (with a potential for up to 40 GHz). An anechoic chamber for EMC (Electromagnetic Compatibility) testing has also been built in cooperation with TalTech Department of Electronics to be used for both industrial service and novel research areas, such as DC microgrids.

The main research areas being studied are: Voltage quality / waveforms; Voltage quality influence on devices and systems; EMC is also of importance – this is due to the increasing use of power electronic converters for renewable energy systems such as solar panels and small-power wind turbines; combination of different technologies to the same power supply grid; thermoelectric micro-production from e.g. domestic boilers.

Over the course of 5 years the research group Electrical Power Engineering comprised 14 researchers of which 8 have a PhD.

The strengths of professorship include excellent labs; good mix of skills, and practical competence; established cooperation with external partners. The weaknesses include: Estonian language necessary for research staff; heavy workload for student labs; expensive infrastructure requiring both heavy investments and costly maintenance.

In terms of opportunities, the following have been identified: the increase in green technologies being implemented in Estonia and internationally, where wind and solar require integration into the electrical grid; increased need and attention from the defence sector. Threats primarily are focused on: *the lack of potential staff*, where decreasing student interest for Electrical Engineering diminishes the potential for new recruits; *the age structure* of the group, where many staff are approaching retirement age; *emerging safety regulations*, resulting in higher expenditure for lab equipment.

The publication record of the group is good, where the output and level of scientific journal papers is improving – the group is consistently increasing the number of publications in journal articles. The publications within the group's portfolio are in reputable journals in the field of electrical engineering, such as IEEE Access, IEEE Sensors journal, etc. No information about patents is provided. The citation figures of Prof. Kütt are moderate, but there is a clearly increasing trend in the last 3 years.



3.1.2.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

This can be described as good where the group has a good level of domestic partners, including: ABB, Estonian Standards Association; Consumer Protection Authority; Estonian Qualifications Authority/Electrical Engineering; the Estonian Defence Forces. Overseas research cooperation partners include Aalto University and University of Vaasa, Finland; TU Dresden, Germany.

3.1.2.3. PHD SUPERVISION

Doctoral Studies: *Excellent ***Good** *Satisfactory *Unsatisfactory

Interviews with PhD students highlighted that the students were able to have frequent meetings with their supervisors, many times per week (if necessary). Lab equipment was considered as appropriate. Most of the 60 credits required for courses were considered as useful for the PhD students.

3.1.2.4. RECOMMENDATIONS

Expensive infrastructure and the need for large investments, as well as high maintenance costs, require new sources of funding and this should be pursued. The recruitment of qualified research staff (especially a search for new motivated PhD-students) is a critical issue for sustainability of the research group. A search for new international partners (both academic and industrial) would help to improve the impact of the research.

3.1.3. Professorship of Information Society Technologies (Dirk Draheim)

3.1.3.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: ***Excellent** *Good *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: ***High** *Good *Fair

Estonia has an international reputation as a leader in digital information society technologies. The mission of this Professorship is to maintain a leading role in ICT system architecture and design of the next generation of digital society ICT (including large-scale ICT systems, ICT system landscapes, ICT ecosystems, and information exchange platforms).

The Professorship established the research group of information systems at the School of IT, Department of Software Science, in 2016. Since then, the research group has been headed by Prof. Draheim. The research group conducts research in information systems technologies to enable the future information society which is at the crossroads of distributed computing (including cloud technologies, software-defined networks, Internet of Things, blockchain technology). It additionally includes next-generation data tech-



nologies (including data exchange platforms, automatic machine learning platforms, business intelligence platforms, collective intelligence platforms).

Over the course of five years, the research group consisted in total of 24 members, of which 12 have a PhD and 12 are PhD students. The group includes 2 professors and 7 associate professors.

The number of publications is high, and the scientific quality considered as excellent, despite the higher level of conference publications (which is considered as normal for computer science). Particularly, the research group has been publishing in IEEE Access and ACM Computing surveys – both are reputable journals in computer science. The research impact in terms of bibliometrics is moderate. Prof. Draheim citations have with a clear growing trend.

3.1.3.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

The research group has collaborations with leading research groups in the field worldwide, e.g. with TU Delft, University of Innsbruck, Kyoto University, Capgemini, McKinsey, and Mitsubishi UFJ Financial Group. The research group seems to work at very good international level, having many international research partners.

Members of the research group are participating in different Estonian organizations, networks, workshops and projects in their research field. They are using their knowledge for consulting and other needs of society as well as participating in joint domestic research projects.

3.1.3.3. PHD SUPERVISION

Doctoral Studies: ***Excellent** *Good *Satisfactory *Unsatisfactory

Doctoral students are treated as equal members of the research team and the research community. A strong team spirit has been encouraged and fostered. Each PhD student receives formal training in research methodology, research techniques, research ethics and philosophy of science. Particular effort is spent on scientific agenda setting and monitoring. In addition to and beyond the usual research and planning meetings, the research group has weekly “PhD round tables” with all PhD students that enable a free flow of thoughts and exchange of ideas. In 2020, the research group has started to conduct annual one-week PhD symposia, to streamline the research endeavours of the group strategically.

The group of PhD students is international and there are only a limited number of Estonian students. Overall, the number of PhD students is high, where each PhD student has one or more supervisors. Upon interview, the selected PhD students were happy with their supervision, indicating that the supervision is at a good level.



3.1.3.4. RECOMMENDATIONS

It is recommended that the research group should publish their research results in international peer-reviewed journals. Although the tradition in computer science is to have conferences as the main publication venue, the group is working at the intersection between data science and business informatics and targeting proper interdisciplinary journals would increase the impact of the research.

3.1.4. Professorship of Chemical Engineering (Oliver Järvik)

3.1.4.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: *Excellent ***Good** *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: *High ***Good** *Fair

This Professorship aims at performing research for the development of improved chemical products by applying tools of applied chemical engineering thermodynamics. The research covers a range of topics from process design to product design.

The quality of fundamental research within the Professorship of Chemical Engineering is sufficient in terms of quality and contribution to science, the publication track record and other research activities, and could be expressed as good. The level of articles published during last 5 years and totally by leaders of the Chemical Engineering research group, including measurements of citations and h-index, are not particularly high but could be considered as sufficient. The publications are at an international level in terms of quality and contribution to science.

However, though the scientific track record and research achievements can be considered as sufficient, the future scientific activity of research group is not clear, since the research group is located within Department of Energy Technology. As such, it is suggested this Professorship of Chemical Engineering may be better served by being in its own, separate, department within TalTech.

This research group along with its leaders is already internationally recognized with ambitious scientists. It is anticipated that new collaborations with strong foreign research groups will start soon, where there is strong potential for increased international recognition in the research field in the future. Other national and international research activities of the group, especially from the application and technological point of view, are suitable for their research field.

3.1.4.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

This research group is responsible for teaching and research in the field of industrial chemical engineering technologies. Also, the members of Professorship of Chemical Engineering are focused on the development of novel energy materials.



The group's general research approach combines laboratory experimentation and computational modelling. The laboratory is equipped with good facilities and apparatus necessary for high-level scientific investigations. The Professorship has strong relationships between science / technology and society, and offers several opportunities to this relationship. The research group currently implements several important research projects.

3.1.4.3. PHD SUPERVISION

Doctoral Studies: *Excellent ***Good** *Satisfactory *Unsatisfactory

Each doctoral student has supervisor, who is available at any time in the lab. PhD candidates are required to report yearly on the progress of research. The doctoral students interviewed by the Evaluation Panel were employed full-time or part-time while they were completing their doctorates. The graduation rate for doctoral students within this group is good. The leaders of the Professorship have supervised successfully many PhD students, where the quality of PhD supervision could be described as good. The overall environment within the research group is excellent.

3.1.4.4. RECOMMENDATIONS

For the past two and half years, the research group has been led by a senior researcher, Oliver Järvik, and it is therefore understood that the group is still in the process of establishing itself as a team with a new leadership. The priorities at this point should be in increasing the international activity of the group, securing research funding for a sustainable operation in upcoming years and the search for motivated PhD students.

3.1.5. Professorship of Metals Engineering (Jakob Kübarsepp)

3.1.5.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: ***Excellent** *Good *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: *High ***Good** *Fair

The metals Engineering group works on relatively traditional metals processing methodologies including powder metallurgy, coatings, materials and structural characterisation. The publishing activity (journal articles) of the research group has been for years above average for the university and school/faculty – over 50% of articles have been published in journals ranked Q1 in the Scopus database. Patenting activity – important (frequently only allowed) output of university-industry projects – has been markedly above university average. The Scopus database shows that about 30% of the publications by the research group have been co-authored by colleagues from foreign universities and/or other R&D institutions. Co-authors of publications are from (1) all Nordic-Baltic countries, except Iceland, (2) several European countries (Austria, Czech Republic, France, Germany, Hungary, Poland, Spain, Switzerland, Russia, Turkey,



Ukraine), (3) some Asian countries (Republic of Korea, Saudi Arabia, Malaysia, China, Indonesia), and (4) North American countries (USA, Canada, Mexico). Two from five patents/patent applications are also international - co-authored by colleagues from foreign countries (Switzerland, France).

In addition to activities shown in the self-evaluation report, the outreach activities are complemented by the organization of international conferences in the field. In particular, the International Baltic Conference on Engineering Materials and Tribology (BALTMATTRIB) was traditionally organized every third year by TalTech, and particularly by the Powder Metallurgy and Hard Coatings research groups. The first conference was organized in 1992. Starting from 2019, the BALTMATTRIB conference was merged to DAAAM conference, and the first Modern Materials and Manufacturing (MMM) conferences were organized in 2019 and 2021.

The future directions of the scientific activities of the Metals Engineering group were not particularly sufficiently articulated in the self-evaluation report which focused primarily on the description of activities from 2017–2021. However, this was later commented upon in the SWOT analysis (description of opportunities) and also briefly during the interview. The future R&D will be to a great extent linked with previous R&D directions, staff expertise and experience as well as available R&D infrastructure: (1) advanced PM composites for tools and structural parts; (2) tribocoatings and green tribology; (3) green materials and technologies, incl. recycling of materials; (4) tribological (wear and friction), mechanical and structural characterization of materials and coatings; (5) other R&D and testing activities connected with materials technologies (incl. powder metallurgy) of predetermined priorities of industrial and/or academic partners.

3.1.5.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

Materials recycling (retreatment, separation and reuse) activities of the Professorship of Metals Engineering (until 2017: “Department of Materials Engineering”) should be considered as one of the main R&D topics. R&D&I activities in this direction were launched over 50 years ago in the Department of Materials Engineering. Facilities of Research and Testing Laboratory of Materials Recycling have been widely used in R&D&I projects of the professorship/research group for decades. As an example: (1) development of thick hard-facings (retreatment of cemented carbide and cermet scrap used as powder for reinforcement of thermally sprayed and/or welded hard-facings); (2) retreatment of a wide range of materials, as an example, Nb slag for separation of metallic Nb and reuse of other separated materials in refractories, retreatment of printed circuit boards waste (WPCB-s) for separation of non-ferrous metals (Cu, Au, Ag, Ni etc.) etc.

The professorship has substantial partnership with industry as well as with the public sector. This aspect is addressed in sections of the self-evaluation report: “Domestic and international collaboration”, “Connection between doctoral studies and the society”, “Comments on revenue” and “The societal impact of R&D”. Laboratory facilities (PM laboratory, Laboratory of thick and thin hard coatings etc) have been and are employed in industry-university R&D projects, testing, materials/products



characterization and producing product prototypes. Most of the R&D infrastructure development projects, in particular those aimed at advancement of “materials preparation” laboratories (PM, coatings, recycling) were to a great extent successful thanks to the support and contribution from Estonian industry. The technology readiness levels TRL 5 and 6 have been demonstrated in these laboratory environments. The scope of university – industry partnership can be evaluated by 13.7% fraction of industrial financing (from Estonia and abroad) of the total funding of the professorship/research group. This is above the average at the university (ca 9%). The Estonian Centre for Standardization and Accreditation, Institute of Estonian Language, Ministry of Defence, Education and Youth Board of Estonia can be highlighted as university-public sector partnership examples of the professorship.

3.1.5.3. PHD SUPERVISION

Doctoral Studies: ***Excellent** *Good *Satisfactory *Unsatisfactory

The professorship is involved in teaching materials engineering courses in a number (12) of study programs of the School of Engineering. All the doctoral degree students of the Materials Engineering research groups are taking part in the Graduate School of Functional Materials and Technologies (GSFMT), organized in cooperation with University of Tartu (<https://fmdtk.ut.ee/>). Mutual activities, such as annual conferences and seminars are organized, which involve partners from industrial sectors, incl. industrial doctorate students. Each doctoral student has a main supervisor, who is regularly available in the lab. PhD candidates have access to the programme structure, standard study plan, specialization and other important information which can be found on the Webpage. PhD candidates are required to report yearly on the progress of their research. The doctoral students interviewed by the Evaluation Panel were employed full-time or part-time while they were completing their doctorates. The leader of Professorship has supervised successfully many PhD students.

3.1.5.4. RECOMMENDATIONS

The overall impression of this research group was that some good work is being undertaken, though this is generally within more traditional metals engineering domains. It is recommended to review the active research portfolio to ascertain future research direction and which research directions could be discontinued.



3.1.6. Professorship of Woodworking (Jaan Kers)

3.1.6.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: *Excellent ***Good** *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: ***High** *Good *Fair

The research group consists of 18 members, of which 5 have a PhD and 4 are PhD students. There is additionally 1 researcher who is based 50% within woodworking and 50% at the laboratory at polymer and textile technology. The professorship has been filled for over 30 years, with prof. Kers starting in 2012.

The research group has four main research and development areas based on veneers, cross laminated timbers, wood chemistry and composite materials via waste products from wood. Research is undertaken in collaboration with the Laboratory of Polymer and Textile Technology and the InnoRenew Center of Excellence in Slovenia. All the research fields being studied can be considered as being both nationally and internationally important and industrially relevant. The research infrastructure is impressive and offers an excellent environment for the research.

The research group has a strong international network of professors / postdocs who are working within the same fields at different universities and research institutes. Internationalization is strengthened with the exchange of professors and researchers, especially including the secondment and transfer of recently graduated PhDs abroad for postdoc positions. The group is cooperating, in research and education studies, with the Northern European Network for Wood Science and Engineering, and actively participating in FPS Cost Actions FP1407, FP1303, FP1306 and R&D partnership with InnoRenew, USDA FPL and many industrial collaborators. The research group is working at a high international level with several different international partners.

3.1.6.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

Wood / forests are an abundant and precious natural resource of Estonia and it conveys a significant value for the Estonian economy, especially the mechanical processing sector. The recent changes within the international wood market, the EC climate change mitigation policy, circular economy and green deal initiatives are creating pressure to use renewable and ecological raw materials, with this being an opportunity for this research group and Estonia in general. The Estonian and global market for wooden construction and transportation products is growing quickly. There is a need to develop high performance sustainable veneer-based products for construction, with low emissions and with renewable bio-based resins. The R&D in the research fields is considered to be of great importance for Estonian economy, especially considering an increase in gross value-added and in employment.

3.1.6.3. PHD SUPERVISION

Doctoral Studies: *Excellent ***Good** *Satisfactory *Unsatisfactory

The professor supervises the 4 PhD students as a research team taking apparently considerable care to ensure that there is a good working environment, mutual support and mutual understanding. Despite the volatility of project-based funding, he has been able to provide a high-level working environment and research team support for the PhD students, but requires more time to refine doctoral students' research tasks and research plans and to support publication. He is keen to engage postdocs more in the research work and PhD students' supervision in the near future.

The topics of three PhD theses were initiated by the research interest of the Estonian companies and is also connected to many Master's students' thesis work. Overall, the supervision of the PhD students is at good level. Students were happy with their supervision and supervisor's support and are also supported in being able to participate and report their results in national and international conferences.

3.1.6.4. RECOMMENDATIONS

The supervision of the several PhD students and Master theses across different fields of wood technology is challenging, where it is apparent that the current number of students is one of the main limiting factors at present. The research group requires more post-doctoral support and senior researchers for supervision purposes, which the professor is trying to achieve. The supervision would also benefit by being more formal, with fixed appointments and precise timetables for PhD students.

3.1.7. Professorship of Oil Shale Technology (Alar Konist)

3.1.7.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: *Excellent ***Good** *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: *High ***Good** *Fair

The quality of fundamental research within the Professorship of Oil Shale Technology is sufficient in terms of quality and contribution to science, the publication track record and other research activities, and could be expressed as good. The Oil Shale Technology research group comprises 10 researchers, of which 6 have a PhD. The number of articles published during last 5 years and in total by leaders of the Oil Shale Technology research group, alongside the citations and H indices are not particularly high but sufficient. The publications are at an international level in terms of quality and contribution to science. Even though the scientific track record and research achievements are sufficient, the future of scientific activity of the research group was not revealed sufficiently.

However, this notwithstanding, the evaluation committee judge that the group has new energy in a leader who is a young, active and very ambitious scientist working in the forward-looking areas of Sustainable Energy and Fuels and Energy Technology.



New collaborations with very strong foreign research groups have been instigated. The group has led several research grant projects and applied studies on sustainable energy, cleaner energy production, and utilisation of solid residues like ash. Therefore, the research group has a potential for stronger international recognition in the research field, and particularly concerning renewable energy and CO₂ capture. Other national and international research activities of the group, especially from the application and technological point of view, are suitable for their research field.

Although the professorship has not secured any EU funding, the cooperation with Finnish Meteorological Institute; Tampere University; Helsingin Yliopisto – which has resulted in multiple papers – motivates the evaluation committee to elevate the international level of research to Good.

3.1.7.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

The Oil Shale Technology research group is responsible for teaching and research in the field of Sustainable Energy and Fuels and Energy Technology. The research group is currently leading a project on the effects of activation conditions and preparation of porous carbon from oil shale and biomass pyrolysis. Porous carbon could be used for hydrogen storage and for electricity generation from wind power parks. The group's current R&D pursuits are strongly focused on CCS and CCU technologies, especially oxyfuel CFBC technology, where they are also studying the activation of oil shale and co-pyrolysis/co-gasification of biomass and oil shale.

The Laboratory of Fuel and Air Emission Analysis of the Department of Energy Technology is providing services in four accredited testing activities: chemical analyses of fuels, ash, precipitation, measurement of air emissions, determination of the metal condition of pressurized equipment and thermal measurements.

It appears that the aims of this research group very often overlap with scientific activity of the chemical engineering research group, which therefore suggests there is a potential for consolidation or collaboration. The laboratory is equipped with good equipment and apparatus necessary for high-level scientific investigations. The Professorship today has deep relationship between science and technology and society, and offers several opportunities to this relationship. One area for the group to transition to would be in the more sustainable field of biomass processing - however, in Estonia there is current a shortage of biomass and thus a full transition from investigating oil shale to biomass does not appear to be possible in the short term and should be considered as a medium to long term potential

As an active researcher, Professor Konist has been or is consultant of Eesti Energia Ltd. (ENEFIT). He has also actively participated in energy related debates, including oil shale power production, where he has given TV and radio interviews, written articles to daily magazines and has been invited expert to Estonian Parliament twice in 2021. In 2021 professor Konist was laureate of the Estonian president's award for the best young scientist.



3.1.7.3. PHD SUPERVISION

Doctoral Studies: *Excellent ***Good** *Satisfactory * Unsatisfactory

PhD candidates have weekly meetings and are required to report yearly on the progress of their research. The doctoral students interviewed by the Evaluation Panel were employed full-time or part-time while they were completing their doctorates. The graduation rate for doctoral students within this group is sufficient. The leader of the Professorship has supervised only a few PhD students, but the research groups record of PhD defences over the 5-year period is acceptable. The quality of PhD supervision could be expressed as good, where PhD students have good access to their supervisors and they appear to get the sufficient support.

3.1.7.4. RECOMMENDATIONS

The international activity of the Professorship could be stronger. The recommendation is to substantially enhance the research network beyond Scandinavia and Baltics. The search of motivated PhD students should be the main task for the group leader in near future.

3.1.8. Professorship of Production Engineering (Tauno Otto)

3.1.8.1. RESEARCH QUALITY AND PUBLIC OUTREACH

Research Quality: ***Excellent** *Good *Satisfactory *Unsatisfactory

Public Outreach: ***Excellent** *Good *Satisfactory *Unsatisfactory

International level: ***High** *Good *Fair

The research group Production Engineering comprises 20 researchers of which 13 have a PhD. The fundamental research within the Professorship of Production Engineering is excellent, in terms of quality and contribution to science.

The publication track record is good, with publications e.g. in CIRP Journals (the International Academy for Production Engineering) and ASME conference proceedings (the American Society of Mechanical Engineers), though the publications do seem to be more conference focused than in journals.

An impressive infrastructure has been developed including; FMS & Robotics Demo-Centre, Industrial Virtual & Augmented Reality Lab IVAR, Protolab 3D prototyping Centre (nylon and metal printing) used by different research groups, and a Virtual learning factory toolkit. The professorship is leading one national research infrastructure program “Smart Industry Centre-SmartIC”, for R&D in industrial automation and digitization, as a distributed project with Estonian Universities and with international cooperation.

Two main research areas include the VR “digital twins” of production systems, and moving robots. The research group has a strong international scientific cooperation, with CNR-STIIMA in Italy; with National Institute of Standards and Technology-NIST Engineering Lab in the US; with Fraunhofer IFF Magdeburg; with Chalmers University of



Technology Sweden; with Tampere University and Aalto University Finland; with Aalborg University; and with SFI Research Centre for Smart Manufacturing in Ireland. Within the H2020 program, a cooperation project with CERN for the use of industry 4.0 technology within accelerator development was started in 2021. Students take part actively within the Erasmus exchange program. Professor Otto recently was invited member of CIRP-the International Academy for Production Engineering.

3.1.8.2. INTERACTION BETWEEN RESEARCH AND SOCIETY

The research group has industrial cooperation concerning implementation of Industry 4.0/5.0. The research group is an Integrator of industry 4.0 technology: Self-driving cars, 3D-printing, Industrial robots, Digital twins, Smart electrical grids, and AI for remote maintenance and monitoring, e.g. of machine tools. A mobile robot platform “Box-robot” (90 kg pay-load) for production logistics was developed and implemented at Stockmans, Helsinki, for food-box packing (after a ban on disposable plastic packaging).

3.1.8.3. PHD SUPERVISION

Doctoral Studies: ***Excellent** *Good *Satisfactory *Unsatisfactory

During the interview with PhD students it was stated that students have good support from their supervisors, with weekly meetings. A very friendly environment for PhD students was observed where they have good support within the group. They have good possibilities for longer or shorter research visits at the group’s research partners abroad. The possibilities for future work after graduation were considered very good, both in academia and in industry. However, it was noted that there are no female PhD students.

3.1.8.4. RECOMMENDATIONS

The primary recommendation is to transition towards publishing in journals rather than conferences for the group’s research outputs. This will help in increasing the group’s international profile. Also, the group should consider it’s gender balance and seek to appoint some female PhD students in the coming years.

3.2. Overall assessment

The School of Engineering has 5 departments and 3 colleges where in total, there are 34 research groups within this School. This targeted evaluation focused on 7 professorships/research groups from the School of Engineering, including approximately 1–2 groups from each of the 5 departments. Additionally, there was one evaluation of a professorship from the School of Information Technologies, that itself comprises 25 research groups.

3.2.1. Research Environment and Organization of Research

The TalTech Academic Strategic Plan defines five R&D priority areas:

- 1) Smart and energy-efficient environments;
- 2) Dependable IT solutions;
- 3) Valorisation of natural resources;
- 4) Future governance;
- 5) Innovative SME-s and digital economy.

The primary objectives of these priority areas are defined as being able to:

- (1) develop new technologies and create conditions for their utilization;
- (2) foster breakthrough innovations;
- (3) contribute to solving economic challenges in Estonia through academic activities;
- (4) achieve the level and impact comparable to the level and impact of the influential centers in the Baltic region.

The overall performance, impact and level of each of the Professorships and associated Research Groups have been assessed by the evaluation team. The assessment was undertaken in terms of the outputs of scientific research, the interaction between research and society, international cooperation, and the sustainability of the field, including doctoral studies.

In summary, the assessment by the evaluation team is that:

- For all of the 8 professorships / research groups evaluated, it is considered that their research is planned for and carried out in good agreement with TalTech's Academic Strategic Plan and its primary objectives.
- Research within the 8 professorships is generally well organized where the evaluation team assessed that in many cases, the infrastructure available to groups was impressive, with modern lab facilities and equipment of a high standard.
- Research Quality was not consistent across the groups and varied between being "Good" through to "Excellent", dependent on the particular Professorship/ Research Group being evaluated.
- Similarly, Public Outreach also varied within the range from "Good" to "Excellent".
- The International level of activity and engagement was generally very encouraging, ranging from "Good" to "High" for the research groups.

3.2.2. Efficiency of the use of the instrument and sustainability

The various research groups sustainability is primarily dependent on the funding structure within Estonia / TalTech. For most of the research groups evaluated, the use of short-term research contracts dominates the funding landscape. The conclusion of the evaluation team is that this results in a large degree of uncertainty, as well as much



effort spent on applying for new contracts. In addition, this also results in the sustainability of some PhD studies not being guaranteed due to them being supported by research contracts that are often shorter than the nominal 4-year PhD study period.

3.2.3. PhD Supervision

From the interviews with PhD students at the 8 professorships carried out during the evaluation, it was ascertained that:

- PhD students generally have good and frequent access to their supervisors;
- PhD students are predominantly happy with their supervisors / supervision;
- A friendly and positive atmosphere is apparent where there appears to be a strong team spirit between PhD students within many of the research groups;
- The contacts with supervisors are regular but often of an informal nature, although regular “formal” meetings e.g., on weekly basis, are held only by some of the research groups;
- Annual evaluation of the PhD students’ progress is carried out at least in some of the research groups.

PhD supervision was assessed by the evaluation team as “Good” for five of the professorships, and as “Excellent” for three of the Professorships.

4. Recommendations

4.1. Recommendations for the TalTech

- *School-level operational plans:* The university has an Academic Strategic Plan including 5 focus areas, where the activities of all the professorships/research groups are consistent with this plan. It is recommended that there should be, in every school, an operational plan for research and development, where the school will set objectives and make plans for future research and other activities. The university should promote these core areas.
- *Increased level of high-quality scientific journal articles:* Research staff should be encouraged to publish in well-known scientific journals to achieve higher quality and recognition. It is understood that each doctoral thesis can include 3 conference papers and possibly one journal article, as normal practice – the university should consider changing this to include at least two refereed journal publications. The university should also encourage post-doctoral researchers and senior research staff to carefully select the location of publications more strategically. Overall, the general approach should be to raise the target level of publications proportionally to the academic experience of the main author(s). Publications in open-access journals with high impact factors should be given financial support.
- *Increase of industrial and societal collaboration:* More efforts should be invested in R&D projects financed by industry and the EU. The strong international networks of the research groups could be used to apply for additional funding from EU, where it is considered that higher-quality papers would enhance this.

The university and industry should have a common understanding of how the cooperation works that benefits both partners. Intensive discussions with industry on collaborative projects and funding should persist. To facilitate these processes, the university should establish an initiative (cluster or research centre), where regional industrial and governmental players become permanent members. Brokerage events, inter-disciplinary workshops and industrial keynote lectures could be used as primary activities of such a cluster.

- *Organization of PhD studies and supervision:* According to university rules each doctoral candidate, in cooperation with his or her supervisor, shall draw up the doctoral candidate's action plan in the study information system. An action plan consists of the following parts: (1) main information on the doctoral thesis: the topic of the doctoral thesis in Estonian and in English and an annotation of the doctoral thesis; (2) a research plan, which must cover the entire period of doctoral studies, and an overview of the literature; (3) an annual report on the



implementation of the action plan, which shall include the supervisor's assessment of the report and the activities planned for the next period. Doctoral candidates are evaluated annually based on their action plans.

The suggestion is that there could be an enhanced doctoral school, either one at the whole university or one within each school, where it is proposed that this would enhance cooperation and cohort building between the generally small PhD student groups contained within different research groups. The organization of common basic studies for the PhD students would also reduce the workload of academics. Within this "doctoral school" there could be common seminars e.g., once a year and other arranged activities.

- *Funding:* From 2016, the university requires that all doctoral candidates studying full-time be guaranteed an income of at least 1,100 euros (net). Of this, 660 euros is the state doctoral allowance, which is guaranteed by the university to all doctoral candidates during the nominal study period. The remaining income must be provided to the supervisor either as a salary or a scholarship. From 2022, according to national laws and the rules established at the university, all doctoral candidates working as early-stage researchers must be guaranteed a salary at least equal to the Estonian average salary. No action is required here, but in order to raise the prestige of scientists and lecturers, alongside the prestige and competitiveness of the professorship positions internationally, it is recommended to raise the salaries of senior teaching and research staff in Estonian higher education institutions. They should be competitive not only with respect to the Baltic region, but also within Northern European countries. If this would be the case, the professorships of national significance could become even stronger in Estonia through the attraction of international talent.

4.2. Recommendations to the Ministry of Education and Research

- An increased total number of PhD positions financed by the Estonian state is much desired. Doctoral schools on a national level, with common seminars and PhD courses, could be a solution to stimulate contacts and cooperation between PhD students from different universities and departments.
- New funding sources for specialized equipment and their maintenance is required for many research groups within the university to stay competitive and serve up-to-date industry standards.
- An additional support for the professorships should be allocated for disseminating their results for wider public consumption (including high school teachers or students). We recommend that results used for public dissemination could be presented in both Estonian and English. Additional resources to support teaching, learning, research and professional leadership, developing professional national programmes, scholarships and awards should be developed in the future.



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