LUT University

REPORT OF ASSESSMENT PANEL

RESEARCH AND IMPACT ASSESSMENT

2019

Lappeenranta-Lahti University of Technology LUT

Research and Impact Assessment 2019

LUT'S RESEARCH HAS A SIGNIFICANT SOCIETAL IMPACT

PREFACE

The Lappeenranta-Lahti University of Technology LUT (LUT University) underwent a Research and Impact Assessment (RIA) in 2019 to evaluate the development, performance, and potential of the university's research and impact. LUT University's previous assessment, the Research Assessment Exercise (RAE), took place in 2012 and focused only on research.

The most recent assessment, however, also brought the university's impact to a focus. The RIA examined the university's activity in 2013-2018, highlighting the years 2015-2018 after the launch of LUT University's Trailblazer strategy. The Trailblazer strategy 2015-2020 focuses on 1) clean energy, 2) the circular economy, emphasising clean water and waste streams, and 3) sustainable business and entrepreneurship.

Evaluation by the international panel covered all research focuses

LUT University's 2015 organisational reform resulted in the establishment of three schools: the School of Energy Systems (LES), the School of Engineering Science (LENS) and the School of Business and Management (LBM). In 2015-2016, based on an international peer-review process, LUT instituted six research platforms to develop interdisciplinary research in its strategic focus areas.

The RIA examined the university as a whole, and its evaluations leaned on written self-assessments of Units of Assessment (UoAs), including impact cases, bibliometric data, other indicators of the quality and impact of research, and interviews by the panel during a site visit.

The RIA was a peer-review process conducted by an external, international, independent panel of high-level experts.

The panel consisted of:

- **Brian Norton**, Professor, President of the Dublin Institute of Technology, Ireland, (Chair of the panel)
- **Fioralba Caconi**, Professor of Mathematics, Rutgers University, USA
- **Mats Engwall**, Professor of Industrial Management, KTH Royal Institute of Technology, Sweden
- **Elzbieta Frackowiak**, Professor of Chemical Engineering, Poznań University of Technology, Poland
- **Anders Kecskemethy**, Professor of Mechanics and Robotics, University of Duisburg-Essen, Germany
- **Patricia Lago**, Professor of Software and Services, Vrije Universiteit Amsterdam, the Netherlands
- **Tage Koed Madsen**, Professor of Marketing, University of Southern Denmark, Denmark
- **Øystein Moen**, Professor of Industrial Economics, Norwegian University of Science and Technology, Norway
- **Piero Salatino**, Professor of Chemical Engineering, Universita' degli Studi di Napoli Federico II, Italy
- **Lennart Söder**, Professor of Electric Power Systems, KTH Royal Institute of Technology, Sweden

I would like to thank the panel once more for contributing their expertise and experience to the assessment of LUT's research and impact.

The Research and Impact Assessment was vital to LUT, revealing the university's strengths, potential, and challenges in research, and LUT's impact on society. The RIA's results and recommendations as well as the material collected during the process laid the foundation for LUT's new strategy.

Jari Hämäläinen
Vice Rector,
Research and Innovations
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Report of the RIA panel: lut.fi/researchevaluation

1. Background

This is the report of the "Research and Impact Assessment" (RIA) of Lappeenranta-Lahti University of Technology (LUT University) conducted in June 2019 to evaluate the development, performance, and future potential of research. The Assessment was a peer-review process, conducted by an independent expert panel whose members are listed in Appendix 1. The panel considered written self-assessments of four Units of Assessment (UoA), including impact cases, bibliometric data, and other indicators of quality and impact of the research work, as well as on interviews with a wide range of internal groups conducted by the panel during their visit. The objectives of the RIA were to:

- assess quality, academic impact and future potential of LUT research
- assess the success of multidisciplinary collaboration
- identify current and emerging research strengths
- assess societal impact of research and the entrepreneurial and innovative capacity
- stimulate and encourage world-class research and impact
- give feedback to the UoAs
- position UoAs internationally and nationally
- strengthen the brand of LUT research
- provide cases and evidence of LUT's development

The assessment encompassed development and performance in the period 2013 to 2018. It follows a previous "Research Assessment Exercise" carried out in 2012. Particular attention was given to (i) activities in the strategy period 2015–2018 and (ii) how the six cross-LUT Research Platforms established in 2015 have succeeded in contributing to the research and impact of the Units of Assessment. The fields included in each UoA are summarized in Table 1.

	Unit of Assessment	**Fields**
UoA 1	School for Business and Management	Business, Management
UoA 2	School for Energy Systems	Energy technology, Electrical engineering, Sustainability science, Mechanical engineering
UoA 3A	School for Engineering Science A	Separation science, Computational engineering, Material physics
UoA 3B	School for Engineering Science B	Industrial engineering and management, Software engineering

Table 1. Fields of research included in each UoA

2. Research Platforms

LUT University has supported six cross-disciplinary and cross-university research initiatives termed "Research Platforms". Overall, they have resulted in quality research as indicated by each citing up to seven publications in high-ranked journals, as well as increased external funding, but to varying degrees. Their performance is summarized in Table 2.

Platform	Involved UoAs	Up to 7 most influential publications	Indicative funding	International cooperation
REFLEX	LES, LENS, LBM	7 in high-ranked journals	20 Mio € grants 8 Mio € LUT	Karlsruhe Institute of Technology, Jülich Research Centre (Germany)
RED	LES, LENS, LBM	6 in high-ranked journals	2 awarded grants (volume not indicated)	MIT, JPL, Tibet & Chinese Acad. of Sc., Yale-NUIST (Nanjing Inst. Sc. & Inf. Tech.)
DIGI-USER	LES, LENS, LBM	7 in high-ranked journals	2.4 Mio € grants	European networks, Asia, U. Dundee (UK), U. Porto (Portugal), Carnegie Mellon, Brno U. Tech. (Czechoslov), KU Leuven (Belgium)
SAWE	LES, LENS, LBM	7 in high-ranked journals	1.1 Mio € grants	Zhenjiang U. China
SIM	LES, LENS, LBM	5 in high-ranked journals	4,5 Mio € grants 3 Mio € Industry	Seville, La Coruña (Spain), Innsbruck (Austria), TU Delft (Netherlands), ITEA3 project lead by Daimler AG involving Germany, Sweden, France and Canada
RE-SOURCE	LBM, LES, LENS	3 in high-ranked journals	7 awarded grants (volume not indicated)	A.SPIRE, COST, Fraunhofer DTU, TU Clausthal (Germany), Polish Academy of Sciences (Poland), Chalmers (Sweden), TU Delft (Netherlands), U. Padova (Italy)

Table 2. Summary of Research Platform Performance

Research Platforms have successfully fostered multidisciplinary cooperation across Schools and Departments. Interdisciplinary cooperation can be clearly seen to have developed common goals and shared methodologies. The degree of integration is more extensive among groups belonging to the School of Engineering Science (LENS) and to the School of Energy Systems (LES). The School of Business and Management (LBM) has only been marginally participating in the existing Research Platforms. The Research Platforms have exploited competences available within the Schools; when specific competences have been missing, the Platforms have demonstrated good networking abilities aimed at teaming-up with national or international institutions and groups with competences that complement these gaps.

The REFLEX Platform constitutes an impressive research group focused on recycling of carbon in a flexible competitive energy system. A clear presentation was provided of the chain of conversion of useless carbon dioxide exhaust gases into an alternative fuel through reaction with hydrogen produced from water electrolysis using solar energy. Food-from-air is a next concept being researched for Power-to-X products. Realization of these highly innovative innovations is feasible. In the REFLEX Platform, there is active cooperation between researchers from Energy Systems and Engineering Science with some participation from Business and Management. Multidisciplinary research is realized in, for example, the NeoCarbonEnergy and Soletair projects. There is close collaboration with at least one company and two new emergent start-ups as well as international cooperation with two German institutions. There has been reasonable societal impact of research, with outcomes presented widely in the media.

The RED Platform mainly involves researchers from LENS and LES. There is interesting work on satellite imaging of emissions to the atmosphere that has potential for great societal impact through improved understanding of global carbon dioxide emissions and local nitrous oxide emissions from coal plants. The RED platform seeks to verify specific data supplied versus satellite data. The team cooperates with the Finnish Meteorological Institute as well as with wide international networks as Caltech, MIT and the Chinese Academy of Sciences. The DIGI-USER Platform is focused on smart energy, smart services, intelligent cities, and living labs. Multidisciplinary cooperation between different LUT units and rich international cooperation is reflected in the co-authorship of their scientific papers and strong funding.

The target of SAWE Platform is to derive clean water from saline and contaminated sources. Such research on water cleaning and desalination is crucial for human wellbeing. SAWE researchers plan to recover elements (nitrogen, phosphor) from wastewater and treat mining wastes. Novel catalytic methods/membranes are developed. There is cooperation with municipal authorities. The well-presented work of platform has moderate international cooperation, as example with China.

The SIM Platform is dedicated to simulator-driven design and co-operation with Finnish industries by the “digital twin” approach. It is well fitted to the “Digital Product Processes in Mechanical Systems” focus area of the School strategy. The platform has been very successful in gaining significant external funding from Business Finland (€2.2 Mio) and Academy of Finland (€2.3 Mio). In addition, the spinoff company Mevea (founded 2005) has contributed to establishing an impressive cooperation with regional industry (80 companies interested in the training courses), estimated in the self-assessment report at €3 Mio, that has securing the employment of 21 people. The number of top publications as well as international cooperation beyond Europe could be improved.

The RE-SOURCE Platform integrates researchers from LENS, LES and LBM. It strongly cooperates with industrial partners (e.g. Fimatec) and displays three multidisciplinary international projects. Further international contacts have been developed in the frame of a COST action and A.SPIRE. The platform works to use biomass sludge as a valuable resource. It has a strong relationship with

the paper industry. The Platform has developed a method to recover rare metals from industry wastes. Metal recycling is realized in the frame of international network BizMet.

Overall, the Platforms are excellent initiatives that have successfully enhanced internal cooperation. Platforms may be needed for new and emerging research areas, established by open competition. Before the end of current funding, it is recommended that the Rectorate should consider continuing to support, perhaps with re-focused research agendas, those Research Platforms that are successful in detailed external evaluations. In the longer-term, alternative and additional mechanisms for cross-disciplinary research structures should be explored.

3. Assessments of UoAs

The Panel assessed all research work in each UoA, whether fundamental or applied, topical or multidisciplinary with equal weight. The Panel has rateed numerically, from an international perspective, the quality, academic impact, societal impact, environment and potential of the research of each UoA on a scale from 1 to 5 (1=emerging, 2=fair, 3=good, 4=very good, 5= excellent international level); providing written explanations of the numerical ratings. The written statements and numerical ratings together form the quality rating of each UoA. The academic impact of the research activities was assessed in terms of international leadership, influencing global research directions, citations, taking part in the international dialogue and networks, and contributing to the development of the fields of research activities. The Panel has also commented on the future potential and research leadership within each UoA. The assessment considered the potential for:

- Researchers to be successful in international competitions for funding
- The research environment to provide support for the chosen activities
- Making an international-level impact on the research community and/or society
- Emerging research fields

The assessment considered the vision and plans for the future, plans to grasp multidisciplinary opportunities, the extent that the UoA recognized its strengths and weaknesses, emerging future opportunities and challenges, and the plans for managing such factors. Issues considered included the age and career profile of the faculty and staff, size of each UoA, and the ability of each UoA to attract high-quality and international doctoral students and faculty. Panel was also invited to comment on each UoA's research environment infrastructure and the investments needed in the future to maintain the attractiveness. The panel considered the ability to secure competitive funding, the capacity to focus each UoA's research activities on timely issues and the existence of international collaboration networks. It should be noted that significant societal impact in many fields covered by this assessment often requires a longer to be evident than the six year period covered by this assessment.

3.1 UoA 1 School for Business and Management

Research in the School of Business and Management (LBM) covers, to some extent, most business disciplines.

3.1.1 Scientific quality and the extent and impact of multidisciplinary collaboration of the research

Examples of high quality research from LBM are:

Coopetition of companies: A paper in the Journal of Product Innovation Management in 2013 that received the Abbie Griffin High-Impact award, has received more than 300 Google Scholar citations. This research stream has had a significant impact on the international research community with other publications in this area, published in quality journals, also rapidly become highly cited.

International entrepreneurship: The self-evaluation report states that LBM professors have been recently evaluated as the top international entrepreneurship research team worldwide. The assessment panel agrees that international entrepreneurship research in LBM has achieved a high international level as evidenced by publications in respected journals such as Journal of International Business Studies, International Business Review and International Marketing Review.

Knowledge management: Award-winning research in knowledge management is ranked highly with papers in Journal of Knowledge Management, Industrial Marketing Management and Technovation.

LBM researchers have published in a variety of high-level journals in addition to winning international prizes for publications and awards for doctoral dissertations. In addition, LBM researchers hold presidential roles and board memberships in international academic and professional associations.

Researchers from LBM have had limited involvement in the multidisciplinary collaborative Research Platforms. Many research activities in LBM seem to be somewhat remote from those conducted in the other Schools. This is only a problem if (i) the Platforms miss research perspectives from experts on customers, markets and users that could be beneficial and/or (ii) LBM does not address readily-available research challenges arising in the resourced Platforms that lie in their remit. In general, the observed degree of multidisciplinary collaboration is that normal in business schools. However, as LBM is within an engineering/technology-oriented university, our assessment is that there is potential for a significant increase in such collaborations.

Based on number of publications, quality of journals and citations, we observe variations within LBM from groups with a very high or excellent international level to others that have yet to reach such levels. Based on the interviews, we also note a high teaching load within LBM. In total, the assessment panel consider the LBM research quality as holding a very good international level at rating of 4, but lacks the quality found in the strongest international business schools.

3.1.2. Academic impact (impact of the research on the research community)

Some LBM research has high academic impact in term of citations. Involvement in the boards of international scientific associations and the awards won by researchers illustrate significant impact on the international research community. The H-index scores and number of citations show a broad group of Professors and Associate Professors work at a very good international level. Overall, we give academic impact a rating of 4.

3.1.3. Societal impact and the entrepreneurial and innovative capacity

Overall, the societal impact activities of LBM have extensive reach and significance. The School reported societal impact activities across its research priorities in sustainability, international entrepreneurship and business analytics. Sustainability research impact is related to supply chains and social enterprises, aimed at Finnish decision-makers as well as developing countries. International entrepreneurship research has impacted on specific sectors (e.g., Cleantech) as well as family-owned SMEs and university-enterprise collaborations. Business analytics research has developed concrete algorithms used in different business contexts and new digital forms of organizing and collaboration, in some cases as part of Masters level courses. A research group is linked with a Masters in business analytics.

Research activities have contributed to providing knowledge to better inform decisions related to policies, products and internationalization processes in SMEs. The societal impact of activities have been documented in journal articles. Though researchers have interacted with stakeholders in society, having made their results available through a range of dissemination activities, LBM does not seem to be a major contributor to national policy development in Finland. Overall, we give a rating of 4 to the societal impact of LBM activities.

3.1.4. Strengths and weaknesses of the research environment

During the interviews and presentations, more aspects of research became visible than were apparent from the self-assessment. For example, during the presentations of societal impact, more depth was found in finance/business analytics research.

Interviews with senior, as well as junior, scholars revealed a very positive attitude towards the working environment in the university generally as well as in LBM. Almost unanimously, the interviewees stressed a very positive work climate in terms of flexibility, freedom, trust, commitment, non-aggressiveness, non-rigidity and supportiveness. The flat hierarchy enables

fast decisions together with access to central decision-makers. A weakness of this very open working environment seems to be some arbitrariness around certain conditions and activities. Interviewees, knowing the trade-offs between such freedom and more deliberative processes, suggested LBM should nudge towards more systematic and structured management. As areas that could benefit more formal arrangements, interviewees mentioned multidisciplinary research, teaching workloads, channels for collaboration with industry and, for international colleagues, dealing with international visitors and external funding.

LBM has developed an identity as a challenger business school in Finland. Its ranking as number 3 in Finland is considered by the School as a very satisfactory given its age and size; being in-line with its quite precise goals for its future positioning. The quality and academic impact of the research is high. The panel gained the impression that both the leadership and the faculty are strongly committed to the School's further development. The networks developed have resulted in an increasing proportion of international co-authored articles. The plans for the previous years in terms of increasing the quality of research and its societal impact have been fulfilled. These strengths constitute a good foundation for future development.

Weaknesses are that (i) a scarcity of resources in combination with a very broad research profile may stymie further development (ii) international cooperations set-up by individual initiatives neither form part of a coherent strategy nor are supported systematically and (iii) there is marginal involvement in the Research Platforms. The research environment is pressurized by high teaching loads, which LBM notes, have resulted in work overload and stress.

Teams in LBM are organized around study programs. It was apparent during the interviews that senior, but more particularly junior, researchers missed having more research-oriented team meetings. Present teaching-oriented arrangements were perceived as inconsistent with an effective research culture. Acknowledging this, four research groups have been recently established. Some of the younger faculty, whilst welcoming this initiative, found that the present groups were too-broad for productive research discussions. The panel suggests that LBM considers a clearer research-oriented organizing structure. Even though LBM does have a positive atmosphere that provides freedom for researchers, the internal structures and processes can be improved to achieve even better research results. One additional element influencing the research is a high teaching workload, affecting both senior and junior researchers. Overall, the panel gives a rating 3 to the research environment of LBM.

3.1.5. Future Potential of the Unit of Assessment

LBM has had positive development in recent years; achieving good results in many aspects. Our overall assessment is that the current, positive development should be continued as the unit has high potential. A supportive internal culture does exist, and this represent an important foundation for development.

The international orientation needs to be further developed. Consideration needs to be given to ensure that internal processes and structures best support increased results output and higher research quality.

Our total assessment is that the future potential of the UoA is high. A rating of 4 is awarded, limited mainly by a high teaching load, location and access to funding resources.

3.1.6. Recommendations for the future

The panel would like to present eight recommendations to the LBM; the first four being most important.

1. Continue the focus on increased international networks and cooperation
2. Improving research structure and research culture
3. Being a business school in a university with a technology and engineering profile creates many opportunities for cooperation. These need to be better exploited.
4. Evaluate if incentives for externally funded projects are satisfactory
5. The networks with industrial partners should be more systematically managed
6. LMB should consider to increase focus on public policy development
7. Overlapping activities with other parts of LUT creates a need for coordination
8. Evaluate teaching loads for the junior faculty

International networks and cooperation: The LBM has increased its international outreach and networks the past years. This develop need to continue and be stimulated by a systematic effort as a supplement to the individually based efforts so far. Recruitment, sabbatical leaves, visiting scholars, joint research projects and joint publications are important elements in this development.

Research seminars and research structure: The flexibility and openness of LBM has many positive effects. Still, we will question the research structure efficiency and performance. Regular research discussions and seminars are not well developed. Both the structure and the content of the basic research environment should be evaluated in terms of fostering a more research-oriented culture.

Increase research interaction with the other schools at LUT: LBM compares itself solely with business schools. At the same time, the environment within the university represent many opportunities for multidisciplinary activity, but also establishment of more projects with distinct parts offered from LBM. Joint focus and efforts both from LBM and from the other schools in order to create more cooperation that increases competitiveness, funding and research opportunities is recommended.

External funding incentives: Based on the interviews, most of the external funding resources is used on part time positions of employees. There is not a tradition of reducing teaching load

through using project funding. Consequently, external projects do actually increase the workload of professors while they still have full teaching responsibility. The LBM should consider if external funding could be used to reduce teaching and supervision duties, creating more time for professors to be actively involved in research project activity.

Cultivate industrial networks: Industrial networks are important, not least related to research funding applications. It does not seem as LUT or LBM have a systematic plan in place to create long-term relations to industrial partners. Our suggestion is to assess which potential companies that will have the highest long-term potential as LBM partners, then target these companies with the ambition to build and cultivate such networks.

More focus on societal impact through policy development initiatives: Development of public policy (as exemplified with innovation policy, entrepreneurship stimulation initiatives or export promotion programs) is an area where LBM knowledge can be very useful for society. Additional effects is that such initiatives increases visibility and perceived importance of the university in political decision-making. LBM should motivate researchers to be actively involved in processes related to policy development in Finland.

Coordination with other schools at LUT: Supply management and data analytics research is carried out both in LBM and in other schools. The panel suggests that LUT considers whether this overlapping of research competences could be avoided by concentrating certain types of research in crosscutting centers. We understand the complexity of this issue, however there is a need for coordination to achieve efficient use of resources, even if the present structure remains.

Teaching workload: During the interviews, it was evident that the LBM teaching and student guidance workload is high. It is not part of the panel's mandate to evaluate teaching; however, the high teaching workload of junior faculty may limit research progress. In terms of resource requirements, having 2-3 students writing their master thesis together should be considered as a direct effort to reduce teaching and student supervision workload.

3.2 UoA 2 School for Energy Systems

Research in UoA2 covers energy technology, electrical engineering, sustainability science and mechanical engineering.

3.2.1. Scientific quality and the extent and impact of multidisciplinary collaboration of the research

This group of researchers engages in a wide spectrum of topics from solar energy economy, recycling, nuclear technology, virtual product design, control, electrical drives, and metal sheet processing to high-speed rotating machinery. Some unique developments include, for example,

testbeds for simulated small nuclear reactors, carbon-nanotube stator coils, carbon-fibers for welded steel reinforcement, digital twins, high-speed generators, electrical machine drive control, digitized robot welding, CO_2 capture and conversion and hydrogen generation. Most of these come from classic engineering research environments. Engineering needs of regional industry are likely to remain as important competences as they form the basis for international competitiveness. The comparatively new field of sustainable science has resulted in high-cited, high-level publications that should be acknowledged. Multidisciplinary work, mainly within the School, has produced real companies and a breadth of topics with strong international reputation. However, there is limited quantitative information concerning this in the written report. The School should document more specifically the connection between profile focus areas of research and the fundamental disciplines as well as the projects of societal impact and the results based on concrete projects and publications. Overall, the panel gives a rating of 4 for this item.

3.2.2. Academic impact (impact of the research on the research community)

The Field-Weighted Citation Impact for UoA2 is 1.39 which clearly shows that the publications are highly cited. The high amount of average funding per year per professor, which at € 300.000 is above average in engineering (compared, for example, with in Germany). A strong portion of funding (overall 24%) has been accrued from industry, which shows the strong integration of the UoA in Finnish industry. Moreover, funding from the Academy of Finland has doubled since 2013 with funding from Business Finland remaining stable despite reduction in this segment. The average however hides that in some fields (e.g., high-speed rotating machines, computational dynamics, biomass gasification, control and robotics) excellent global leadership has been attained, which is to be credited. In high-speed rotating machines, computational dynamics and solar economy, global frontrunner status has been attained. Concerning the extent of publications, there are 4.8 publications per year per professor. The number of papers included in JUFO 2+3 is 26% with 74% in JUFO1. This is reasonable but could certainly be improved. It is recommended that some departments at lower levels should take active steps to raise their ambitions.

International activities are evaluated as moderately strong based on the reported international collaboration in publications (28.4%) of the self-assessment. The amount of EU projects has increased from being 2% of the funding in 2013 to 5% in 2018. From the interviews it was learnt that there are increasing activities in the international cooperation, e.g. in PhD recruiting, and in the preparation of an international bachelor program. Although these impressions were not substantiated in the self-assessment report, they are taken into account here on the positive side. Overall, the panel gives a rating of 3 for this item.

3.2.3. Societal impact and the entrepreneurial and innovative capacity

Several projects have societal impact. There is involvement in all multidisciplinary platforms. 13 spin-offs were generated in the period 2013-2018, which produce "hard" products and provide significant employment. The spin-offs have anchored major international companies locally, e.g. spinoffs Visedo and The Switch were acquired by the Danfoss Group and Yaskawa respectively. Given the size of the unit, this is excellent by international standards and certainly shows a strong impact on the society. There is also significant, but unquantified, cooperation with many companies in different industrial sectors over many years, including:

- ABB, a long-term partner in a wide range of research projects and through CDMC research activities
- Yaskawa, a recently-established strategic partnership
- Wärtsilä, Fortum, Vattenfall, Kone, Foster Wheeler, Andritz, Metso Power, Kemira, Outotec, Stora Enso, Savcor, UPM, Rautaruukki, Outokumpu, Man Turbo, and Statoil

LES carries out excellent research and knowledge transfer / market adoption. In a few cases, we noticed a missed opportunity for increased strategic, sustainable two-way collaboration with industry with patents not leading to systematic valorization. Overall, the panel gives a rating of 5 for this item.

3.2.4. Strengths and weaknesses of the research environment

The strengths of the research environment are a very motivated and productive group of professors who have gained strong external funding via good research topic selection. There is a visible ambition of clear profiling of the focus areas with the overall university profile, however, this should be more clearly substantiated by specific profile performance numbers (funding, publication, platforms, etc.) in future. The entrepreneurial ethos is evidenced by strong external funding from scientific funds and industry with visible generation of active spin-offs. The School has very good laboratory equipment.

There is evident demonstration of good performance in teams and multidisciplinary interaction by LES being involved in all six multidisciplinary platforms and in international networks. Both young professors, PhD students and Postdocs have confirmed that there is a very good research culture, with clear rules and plenty of freedom of research and employment rules that are deemed by personnel as being transparent and fair. There was very positive feedback on the lean and flat hierarchical structure ("as PhD you can say hello to the rector") and communication between members of a group was experienced as very good. Respect for authorship, together with influence on publication content starting at the PhD level, was cherished by young researchers. All PhD students confirmed that they had big advantage in using the extremely useful and valuable "English Clinic" when writing their first paper on their own. That the Clinic gives academic credit only once that paper has been accepted and deemed as very good. Involvement of PhD students in teaching was unanimously rated as very valuable and good. PhD

candidates felt that the effect of learning in communication was extremely valuable as well as it being “fun” to teach.

The following are areas where active consideration should be given to their improvement.

The average number of PhD graduations per year could be improved (currently 0.5 per Professor and Associate Professors) in future it may be appropriate to consider measures that raise this to better than 1 to 2 per Professor. There is room for clarification of assistant professor competences, as well as their promotion to associate professor (based on merit and/or based on fulfillment of time at a lower grade).

Not all items reported as societal impact could be related to the profile areas in the self-assessment report. It did not become clear where established activities were placed within the profile topics (and which are novel projects) as the projects and publications in the appendix to the self-assessment report were not related to the profile areas in the strategy plan. For future assessments, these should be associated one-by-one, with non-fitting items in an extra “bin”. For example, the panel could not conclude in which bin(s) the activities of the nuclear safety group were included. Along a similar line, how are the profile areas connected to Power-To-X?

The 1+3 concept for PhD tracks was experienced as positive by the PhD students and Postdocs; however, the “interim” status of students before they are formally studying for a doctorate leads to some minor practical problems, for example no student discount for conferences, visa applications, use of public services at student status. It is recommended that LUT consider creating a limited duration special student status to address this. PhD students discussed the bonus system for publications controversially: one side found it as an incentive; the others found that the money would be better invested in common settings, such as intensification of doctoral support and grants for outgoing students.

Steps should be taken to ensure that critical mass exists to cover all ambitious targets; focusing to a reduced, and more powerful, set of topics could be considered. It should be clarified which part of “Power-to-X” will be handled physically in laboratories via technical developments and which within the general area of system analysis. In Mechanical Engineering there should be a higher concentration on highly cited journals (JUFO 2-3). The future goal should be clarified concerning the balance between the currently focused areas: e.g. nuclear, industrial machines, electric power, and future areas “sustainability system science” and “Power-to-X”. For future planning, particularly with newer focus areas, there would be value in identifying current areas that are likely to decrease, in their present form, in the future. There is also a need to introduce a gender diversity strategy.

The personal interviews and presentations revealed a great amount of highly positive performance data. However the self-assessment report was in parts difficult to analyze, as the narrative generic front-section was not directly related to the quantitative data provided in the appendices. It is recommended for future self-assessment that this includes the specific data of the performance section in conglomerated form in a single table showing the “bins” of the focus

areas filled with project funds, publications, PhDs, Masters, societal impact as distributed equivalents, with an extra bin “others” for the non-matching items (see above for societal impact). Overall, the panel gives a rating 4 for the research environment.

3.2.5. Future Potential of the Unit of Assessment

The UoA is well prepared for the future and the measures taken give strong expectations that the group will continue to improve its competitiveness in the scientific area and its societal impact. The tenure-recruiting plan is bold and well balanced and promises a good covering of both fundamental disciplines and strategic areas for enhancing future developments. The research concerning “solar economy” should have a strong possibility for international funding and collaboration. This area could also have a stronger coupling to, e.g., material science where also use of material in a future sustainable system could be included. It seems from the interviews that they are working in this direction.

There is certainly a possibility to increase the work in the area of “Power-to-X”. However as this is a large area, it should be clarified in which part LUT can concentrate resources to make a real impact. In the traditional areas, it is certainly possible to have more publications in high-level journals. There are several professors with comparatively low H-index, who should be encouraged to submit more papers to high-level journals.

There seems to be a goal to improve international collaboration, but among a sample of 6 PhD students/post-docs, only 1 had been abroad during their study. For future possible EU projects it is essential to increase this type of international projects. Concerning recruitment of post-docs, it is unclear how common it is to have applicants with PhDs from other universities successful in competitions from open announcements. To have international post-docs, who then move to other places, increases the future network.

Overall, the panel gives a rating of 4 for this item.

3.2.6. Recommendations for the future

Individual performances within the academic staff are impressive both at the academic and entrepreneurial level. What is lacking is a common platform of visibility of achievements for the complete UoA team. A periodically updated overview would be of interest and motivation for all team members, not only at the time of evaluation. In this setting, it is recommended to establish and maintain a tabular correlation of papers and projects to the four profile areas. It will remain important to keep the fundamental knowledge in the traditional areas of mechanical engineering, electric power engineering and energy technology: it should be clarified how the emerging areas, solar-economy and Power-to-X, are linked to the fundamental disciplines. For future multidisciplinary platforms, it is recommended that LES allow other Schools, particularly LBM, to lead initiatives that intensify cross-university collaboration.

The history of start-ups is certainly strong, and it is important to continue in this direction. This needs to be supported by a clear patent strategy that assesses and assigns costs and revenue.

There should be a clear strategy that all PhD students should have the possibility to go abroad for, e.g. 3-6 months. This might exist already, but it is not clear from the documents.

3.3 UoA 3A School for Engineering Science A

UoA 3A comprises Computational and Process Engineering, Green Chemistry, Physics and Separation and Purification Technology. It is responsible for teaching programs in Chemical Engineering and Computational Engineering whilst also providing basic teaching in mathematics and physics to all the degree programs related to UoA3. The Unit is involved in all the 6 multidisciplinary Platforms, and leads 3 of them (RED, RE-SOURCE and SAWE). Research in UoA 3A covers a broad range of subjects in three main areas, namely: computational science, separation and purification science and material physics. Research in computational science focuses on inverse problems, uncertainty quantification, computer vision, and machine learning. Core expertise was extended to process engineering and applied computational photonics. In separation science, research has been mostly focused in water treatment and purification, sustainable use of natural resources and exploitation of waste, in the frame of circular economy. Research in material physics focuses on magnetic shape memory (MSM) materials and their applications, in semi-conductor physics and in nanophysics. Most research is relevant to the three profiling areas of LUT: clean energy, circular economy and sustainable business.

3.3.1. Scientific quality and the extent and impact of multidisciplinary collaboration of the research

UoA 3A displays the ability to perform internationally recognized high-impact research activities to a great extent, with a good propensity to multidisciplinary work. A significant number of active researchers are working on cutting-edge ideas and approaches. Research is extremely heterogeneous, ranging from stochastic methods in inverse problems, imaging and machine learning, materials physics, separation and purification technology, green chemistry to computational engineering, represented by 4 Departments. All these scientific areas are different but “circular economy” and “sustainability” seems to be a common leitmotif for UoA 3A. The quality and effectiveness of competence integration was fully appreciated after oral presentations and interaction with faculty and was fairly good, though it could be further strengthened. Integration is more extensive among groups belonging to the School of Engineering Science (LENS) and to the School of Energy Systems (LES), whereas it would be desirable to find ways to stimulate integration with the School of Business and Management (LBM).

The Unit is extensively involved in Platforms, having undertaken the leadership of three of them. UoA 3A have effectively developed networking actions by teaming up with national or international institutions. Multidisciplinary links between four departments exist according to oral presentations but were not enough underlined in the written reports, this indicates cooperation could be tighter. High level fundamental science and innovative ideas have been shown in Physics Department (MEMS materials, piezoelectric materials, home-made 45 Tesla magnet). Scientists presented cutting-edge ideas for further future, e.g. wind farms on the roofs. Separation and Purification Technology has a long tradition in LUT. Scientific group cooperates intensively with a paper industry. Masters and PhD students are in well-equipped laboratories. Applied mathematics unit in UoA3A has a focus in stochastic methods in inverse problems, imaging and machine learning. The current faculty is excellent, being nationally and internationally recognized. The group was recently joined by the group of computer vision and pattern recognition, which also belongs to the prestigious Academy of Finland Center for Excellence on Inverse Modeling and Imaging. They are also the lead on the RED platforms and have several other grants from Academy of Finland, with collaborators in Europe and USA, they have visible in international activities. The applied mathematics group is part of the world class Finnish research school in inverse problems. Thus the presence of mathematics at LUT is of high quality and the mathematical expertise appeals to many research strengths of the university.

Overall, the panel gives a rating of 4 for this item.

3.3.2. Academic impact (impact of the research on the research community)

Unit UoA 3A has clearly developed distinctive areas of excellence. The Department of Computational and Process Engineering hosts an Academy of Finland's Centre of Excellence on "Inverse modelling and imaging", whose accomplishments earned it the remarkable recognition of receiving funding for a third term (2018-2025). This Centre has established a promising collaboration between applied mathematicians and computer scientists which should be further encouraged. The Department of Separation and Purification Technology represents the largest academic research cluster in water treatment in Finland. It is recognized as having the highest expertise in separation technology, with a specific focus on solid/liquid and membrane separations, with extensive cooperation with a paper industry. The Unit has recently broadened its scope with the inclusion of a group of a Green Chemistry Department whose integration with the others seems to be in the emerging phase. The Department of Materials Physics has earned a distinctive and recognized competence in magnetic shape memory (MSM) materials and applications, relevant to electromechanical applications, in magneto caloric materials to replace cooling fluids, and in nanosized piezoelectric materials for advanced sensing and energy generation.

The overall impact of the research activity is remarkable, as demonstrated by the SciVal (Scopus) indicators averaged over the whole UoA: nearly 50% of publications in top 10% journals by CiteScore, average citations per publication of 17, field-weighed citation impact slightly exceeding 2. The productivity and impact of the three main scientific areas of the Unit are fairly balanced.

An overall rating of 4 is given for this item.

3.3.3. Societal impact and the entrepreneurial and innovative capacity

The societal impact of the research, teaching and third-mission activities undertaken by UoA 3A are clearly visible. The first path along which society is positively impacted is through graduates, educated by qualified world-class experts, and their employment in industry or in top class universities and research institutions. The second path is through extensive collaboration with external bodies: a) support to companies on existing businesses, either through consultancies or through the development of joint projects; b) generation of new spin-off/start-up companies by exploitation of the results of research; c) cooperation and development of joint projects with other research organizations (e.g. the Finnish Meteorological Institute, LUKE, SYKE, VTT) and municipalities. Some of the newly established companies have been extremely successful, both in terms of profits and employment. Altogether, the societal impact and the entrepreneurial and innovative capacity of UoA 3A are remarkable given the size of the Unit and its human and infrastructural resources.

An overall rating of 5 is given for this item.

3.3.4. Strengths and weaknesses of the research environment

The strengths are long-term strategic planning for research activities. It develops international networks and collaborations that lead to successful external funding particularly for EU projects. The unit has a good gender balance. Young people reported a very vivid and stimulating environment.

The weaknesses are that there are still many papers in JUFO category 1 (nearly 50%). The international cooperation should be consistently stronger across all activities and groups. In one case, there is a high number of PhD students per supervisor.

It is quite clear that the present assessment portrays a Unit that is still undergoing major transformation and re-organization processes. The re-organization of former Departments and groups into 3 Schools, and the establishment of a single School of Engineering Science with a broader scope seems to have generated positive effects on multidisciplinary integration an sharing of goals and methodologies. The Platforms seem to have contributed to a great extent to this process. The leadership has set clear objectives in terms of research goals and priorities,

management of resources, either personnel or infrastructures, strategies for networking and access to research funds.

The new tenure-track process apparently generated positive impacts in terms of competitiveness of the research teams, transparency of the recruiting and appointment methods, and openness with respect to gender and geographical origin, though there is still much to do along this direction.

The Unit, as part of the LENS School and of LUT, should further promote interaction and generation of critical mass around shared objectives and priorities and stimulate productivity and international visibility through rigorous and selective appointment of new researchers and educators. This goal is very important in view of the seniority of the staff, approaching retirement, in some of the research and teaching areas in which the Unit is active. Overall a rating of 4 is given.

3.3.5. Future Potential of the Unit of Assessment

The Unit displays a positive gradient toward generating top-level research, education and third mission. A greater chance of achieving these goals is feasible if the Unit further pursues the current efforts into multidisciplinary integration, internationalization and competitiveness. A clearer rationale for the two units Computational Science and Software Engineering is required. In the current version of the self-assessment, there is no clear reason of why to keep them separate. Overall a rating of 5 is given.

3.3.6. Recommendations for the future

The Unit, as part of the LENS School and of LUT, should further promote interaction and generation of critical mass around shared objectives and priorities. Productivity and international visibility should be pursued through rigorous and selective appointment of new researchers and educators. This goal is very important in view of the seniority of some of the staff, approaching retirement, in some of the research and teaching areas in which the Unit is active. In the view of the panel, a better organization could be established if the different groups sharing interests for ICT would be brought together in the same Department. The “Spirit of the Community” and identity should be reinforced, especially among seniors, by stimulating exchange of information and events at the university scale. Researchers, and especially younger ones, should be advised to publish less (in number) but better quality (i.e. in high-impact factor) journals. International recognition, hence citation and H indexes, might be improved by producing good insightful review papers together with papers written in the frame of international co-operations.

Some areas, for example in applied mathematics and physics, although of comprising high-quality faculty, are too small and specific expertise focused to meet the challenges of an engineering school. Arguably, a strong engineering school requires a strong broad mathematics capability. Mathematics as discipline is fundamental to research across departments and schools. This also applies to undergraduate and graduate education. The group of applied mathematics includes

two professors (one half-retired, one currently vice-rector), one associate professor, two tenure track associate professors (excellent hires in the past year). As mathematics has a limited number of research personnel, this should be considered at University level in the hiring strategy and allocation of funds. It was unclear from the interviews if LES and LBM faculty who teach mathematics are undertaking research. The term “mathematics” (or applied mathematics) does not appear in the unit nomination; as a first step to addressing this could be to rename the Department of Computational Science to improve visibility of mathematics in this unit.

3.4 UoA 3B School for Engineering Science B

The UoA 3B covers research in Industrial Engineering and Management (IEM) as well as Software Engineering (SE). The IEM field (approx. 80 persons) is structured in five focus areas (1) innovation and technology management, (2) cost and performance management, (3) supply chain and operations management, (4) entrepreneurship, and (5) systems engineering. The Software Engineering team (approx. 20 persons) focuses on industrial practice of software and system development. By tradition, the UoA has had a strong emphasis on education and teaching with the UoA representing the two most popular engineering programs at LUT.

During the last five years the UoA has undergone several reorganizations, which has not been positive for the research environment. Overall, however, the number of professors has roughly remained the same over the years.

3.4.1. Scientific quality and the extent and impact of multidisciplinary collaboration of the research

The research of the UoA focuses how to organize engineering processes, how to enable value creation in technology based organizations, and how to utilize potentials offered by novel technologies in order to facilitate a profitable and sustainable way of renewing businesses. The research is characterized by close collaboration with industry. Right now, ‘digitalization’ is a driving theme to both fields. Based on the provided information, the ‘sustainability’ theme seems to be less developed in the research activities of the UoA. The definition applied covers primarily business sustainability and how to make software more sustainable. This is partially in contrast with the LUT focus themes (e.g. research for environmental sustainability), and needs further investment.

Most research of the UoA has close ties to practical problems experienced in industry. Several professors are also engaged in the cross-disciplinary platforms of LUT; where one is led by scholars from the UoA. In general, multidisciplinary work has produced new businesses, products, work processes and services in various fields. However, there is limited quantitative information concerning this. An overall rating of 4 is given for this area.

3.4.2. Academic impact (impact of the research on the research community)

The UoA is well-respected and some of its scholars are known internationally. The actual research carried out is of good quality. However, given the size of the UoA, the total amount of scholarly output could be higher; right now, it is little under average of the two fields. Based on the information provided, the present research of IEM seems scattered into a large number of areas and issues which makes the profile of the research portfolio vague. Furthermore, the SE-team is today too small to make an impact internally at LUT, as well as in the international research community. The examples of top 10 publications are sound. However, given the research carried out, the UoA should strive for publishing in outlets of higher quality and engage more actively in the international community. It is worth noting that one professor is present in all the three top publications presented from software engineering. For academic excellence, the strategic initiatives concerning e.g. publication, international cooperation, and funding constitutes a good start. Presently, however, it is too weak and not systematic enough to provide a long-term strategy. An overall rating of 3 is given for this area.

3.4.3. Societal impact and the entrepreneurial and innovative capacity

Societal impact is a key strength of this UoA. The reach is extensive and diverse thanks to the extensive industrial contacts in relevant fields in the both private and public sectors. The combined focus on digitalization and sustainability, both especially urgent needs of our society, provides a strong research focus. Exemplary projects like S4Fleet (private sector, creation of novel sustainable business models), and PERCCOM and follow-up projects (education, creation of knowledge for a fair and energy-efficient society), and the research in e.g. social and healthcare services, have had innovative impact in both Finland and internationally. In a very short period, this UoA has carried out impressive research, and gained international recognition (e.g. Kalskrona and ICT4S communities). We also observe a proportional increase in the production and the quality of the scientific publications, although continuity and continued investment need to be maintained for stable academic excellence.

The DIGI-USER research platform greatly contributes to the impact of this UoA. It provides focus and its explicit open model combined with strong leadership and a cross-school team can be further exploited for dissemination that is more systematic, valorisation and longer-term transfer of research results across projects and disciplines. An overall rating of 4 is given for this area.

3.4.4. Strengths and weaknesses of the research environment

The UoA 3B is well organized and well positioned. The research environment clearly nurtures creativity and research freedom combined with high quality supervision. At this stage, however, it needs stability, time and persistence to build a robust research culture fostering a strong

international reputation. We identified insufficient resources (funding and faculty) and unclear long-term vision for what the UoA aims to become.

Among its strong points, we recognize strong connections with industry. There is an open research culture: open research discussions with supervisor, open own international network with juniors; freedom for doctorate candidates to make decisions for own research direction, space for their creativity and agile social interactions. Research Platforms have helped set research focus and priorities provide additional financial resources, and overall participation in Platforms has been good for collaboration that has started new initiatives.

A general weak point (and recommendation) is to provide the UoA 3B with stability. The UoA has had the series of reorganizations that have had some negative impact on research. Limited resources combined with an increasing workload is pressing the staff: in the past few years, the administration load has increased significantly but with little benefits.

Overall, the research environment is given a rating of 3.

3.4.5. Future Potential of the Unit of Assessment

There is a great potential for LUT in having a UoA covering both IEM and SE. However, in order to achieve this, it needs to strengthen its emphasis on research and gain, or create, more "muscles" in research. Many teams have great potential to have a greater impact, for example by identifying specific research directions that combine fundamental research in software for environmental sustainability. In the context of the LUT focus areas, these include empirical methods for impactful collaboration with industry (e.g. by research in novel methods in the emerging platform-based economy), service innovation, data-driven business models, and large-scale data processing. The current position of the UoA within the School of Engineering Sciences together with the existence of the LUT research platforms provide good opportunities to excel in multidisciplinary collaborations in the future.

The UoA has currently tough educational duties, which need to be matched with aspirations for an extended research volume. Given the situation in research financing in Finland, this is a challenge: nevertheless, it has to be addressed. Furthermore, the emerging themes identified by the UoA are promising. At present, however, it is not clear how this will differentiate IEM and SE at LUT from their peers (and competitors) at other engineering universities in Finland, as well as internationally.

The internationalization of the UoA is increasing. It needs, however, be strengthen further. Among the group of six PhD students/post-docs, interviewed, four were Finnish "LUT products", while one Postdoc and one PhD student were internationally recruited. The idea to spend a longer time period abroad during the PhD-studies could be stronger. Concerning recruitment of postdocs, it is unclear how common it is to have PhDs coming from other universities. To host

international postdocs for e.g. two years, who then move to other places, increases the future network.

Consequently, future potential is given a rating of 3.

3.4.6. Recommendations for the future

There is insufficient visibility of (i) research done from masters level through PhD research projects, and (ii) about the various research fields/competences (e.g. in a specific team) that could beneficially work across teams and schools. It seems that having the LUT organizational identity in the three research themes hinders visibility of these crosscutting fields (SE and IEM in UoA 3B). Actions like identifying disciplinary research pillars could resolve this.

There should be more communication/synergy beyond single teams. Partially due to a lack of time for systematic initiatives, the Assessment Panel did not observe a strong culture of exchanging research at both senior and junior levels. Some seminars do take place, but juniors/doctorate candidates seem to have little interest in sharing their research perhaps due to lack of focus or disciplines being too far away from each other. A good suggestion could be to put in place initiatives meant for collegial feedback to enhance quality, and to kick-start synergy.

The UoA should develop strong directions that achieve a balance between applied and fundamental research, so that research is not too driven by industrial needs.

We suggest reflection on, and definition of, a middle- and long-term strategy for building research excellence and strengthening international reputation. The unit should also develop systematic strategies for funding, international cooperation and excellent publications.

Right now, there is a tendency to jump on every research funding opportunity. This lack of focus and strategic direction seems to result in efforts/work being spoiled. UoA 3B might consider combining strategic supervision/guidance with longer-term directions/themes; the unit should try to create themes that can guide supervisors as well as junior researchers and facilitate the development of a distinctive research profile for the department. The mentioned focus on "systemic design" is very promising as an emerging fundamental research theme, with potential to be a new research platform. Some non-native staff members seem to require support to understand funding opportunities and how to collaborate with industry more effectively.

International outgoing research visits are partially supported by good small grants of three months duration for doctorate candidates. However, the UoA might consider allocating resources for longer outgoing visits. International incoming research visits are also a good instrument to attract excellent guest researchers from abroad; these are currently supported only by joint degrees and specific projects. Seed money would also help strengthen international reputation and academic links.

Some junior researchers would like to see more strategic initiatives to increase the international research reputation of LUT (cf. university rankings). If such initiatives already exist; they should be communicated regularly university-wide seminars.

The juniors are unaware of the existence of any independent body (ombudsperson) to turn to in case of conflicts (e.g. problems with PhD supervisor) or harassment.

Some fields seem to be organizationally structured sub-optimally with insufficient faculty to be academically robust. For example, computer science and software engineering, due to historical reasons, are spread across three different schools at LUT. This seems to spread the resources in a way that hinders focus and depth; software engineering within UoA 3B would benefit of more faculty (particularly to attract top talents) to strengthen current research focuses especially in software research for sustainability.

There is not currently a clear distinction between the Business School and the IEM-department. This distinction need to be defined, if not per subject, then maybe by empirical focus, type of industry, or type of organization. Right now, it is very difficult for an outsider to understand the difference.

There needs to be an explicit “strategy in action” demonstrable by a planned roadmap of actions. This should show how to nurture, support, and enhance the growth of a strong research culture that will manifest itself in high quality outputs.

4. Overall Assessment

4.1 International research exchanges.

There is good small funding (3 months) for doctorate candidates to make short visits to other universities, but lacking more resources for outgoing longer visits. There is good work on "internationalization" with for example significant (but unclear) number of international PhD and MSc students. The clearer visibility of the scale of international research student numbers would aid additional international student recruitment. Some central funding for periods in other universities competitively awarded to PhD students should be considered. PhD students are obliged to spend 6 months abroad; the selection of the international units that are destinations for these stays and their conditions and obligations appear need to be clearly presented.

It is not common at LUT for excellent guest researchers to hoste International incoming research visits: (outside joint degrees or specific projects). It would be valuable to provide funds to invite international scholars on visiting professors. Selected well, this could improve international cooperation and increase the number of collaborative papers in high-ranked journals. Seed money for international proposal completion would help strengthen international reputation and academic links.

4.2 Research Strategy

There can be a tendency to jump-on every research call resulting in wasted effort/work. More supervision/guidance along more clarity on long-term directions/themes would guide supervisors as well as junior researchers and facilitate the development distinctive research profiles for each department. Some fields seem to be organizationally structured in a sub-optimal way, or with insufficient faculty in order to be academically robust. For example; computer science and software engineering are spread across three different schools at LUT, this might be due to historical reasons but it seems to spread the resources in a way that hinders focus and depth. Continuity and stability would be maintained by continuing the present research structures. However, the continued designation of two research sub-units in LENS (i.e. 3A and 3B) would not be optimal. Opportunities to create new synergies and perspectives within "new" research centers should be explored. General structure of LUT is rather complicated (Schools, Departments, Platforms, Degree Programmes), however, it works well.

4.3 Research Culture

Clear and bold strategies need to be defined to maintain a culture of academic quality and international cooperation. The (1) explicit open model and (2) dedicated team with cross-school representatives (used in the platforms RE-SOURCE and DIGI-USER) seems especially successful to foster a collaboration culture. It should be reused by the other platforms, too. Also, the idea of "cross-platform projects" like the one between DIGI-USER and RE-SOURCE seem very useful (maybe it can be used to engage UoA 1). Some junior researchers would like to see more strategic

initiatives to increase the international research reputation of LUT. If such initiatives do already exist, it would be good to communicate them regularly in e.g. university wide seminars. Junior researchers are unaware of the existence of any independent body (ombudsperson) to turn to in case of conflicts (e.g. problems with PhD supervisor) or harassment.

The Green Campus Open for industrial innovation and research valorization seems very good, for knowledge transfer (new startups) and ROI (LUT is shareholder of the startups and research-based spin-offs). The Green Campus Open may offer further opportunities (not covered yet) in open source/inner- source software (UoA 3A), and digitalization of business processes (UoA 1). Also, a physical incubator on Campus next to the use of labs would further foster collaboration to ensure the return on investment from the production of patents is clear.

It is suggested to consider discontinuing financial incentives for colleagues (other than full professors) to publish in highly ranked journals. Rather it is suggested to motivate researchers by continuing to create better conditions for work, improve infrastructure, cover cost of participation in important conference, provide seed funds to develop great proposals and proactive celebration of research achievements.

4.4 Journal Categorization

The JUFO journal categorization seems to be very isolated with respect to international journal metrics and biased with respect to specific fields. The evaluation panel analyzed JUFO categories of renowned journals in the area of engineering and found evidence of wrongly categorized journals (e.g. JUFO 1 for leading journals in mechanical engineering and others). Although it is clear that this recommendation cannot change Finnish policy, it is worthwhile noting that it is penalizing unjustly engineering areas, which are not visible in the Finnish selection. There are clear rules in international journal metrics, where each journal is already classified in corresponding fields and ranked within them. A Q1 journal (first quartile) is hereby regarded as leading. There is no need to open a national, isolated ranking that may not to coincide with international standards. It is recommended that LUT leaders consistently communicate this to the Academy of Sciences until the practice is corrected.

4.5 Future Assessments

The self-assessment documents provided were often not very specific; mostly generic terms were used in the main body, with no reference to specific information about actual research activities and their strengths and weaknesses. No mention of teaching load and responsibilities was given, so it was difficult to evaluate the potentials to increase research output. 50-60 doctors per year is not high considering a faculty of 90 Full Professors For the next evaluation, there should be a template for UoAs with definition of, and statistics for “internationalization”, e.g. non-Finnish employees/PhD students. There also should be information on the shares of funding between education and research and the amount of education per UoA (programs / nr of students). There should be the same figures (e.g. Field-Weighted Citation Index) used in different parts. Every unit should make a national benchmark displaying their strengths. For the next evaluation,

consideration should be given to normalizing by duration of academic career, as an H-index of 15 has very different implications if the person is 30 or 55.

4.6 Conclusion

In the various international rankings, LUT occupies a reasonably high position. The target is to preserve this or even to go higher. The University's research demonstrates a strong trajectory with demonstrable evidence of high international quality together with timely and useful outputs that have made some important societal impacts.

Acknowledgements

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APPENDIX 1

Members of Assessment panel

Brian Norton, Professor, Principal, Technological University Dublin, Ireland, Chair

Fioralba Cakoni, Professor of Mathematics, Rutgers University, USA

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Elzbieta Frackowiak, Professor of Chemical Engineering, Poznań University of Technology, Poland

Andres Kecskemethy, Professor of Mechanics and Robotics, University of Duisburg-Essen, Germany

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Tage Koed Madsen, Professor of Marketing, University of Southern Denmark, Denmark

Øystein Moen, Professor of Industrial Economics, Norwegian University of Science and Technology,
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Piero Salatino, Professor of Chemical Engineering, Universita' degli Studi di Napoli Federico II, Italy

Lennart Söder, Professor of Electric Power Systems, KTH Royal Institute of Technology, Sweden

APPENDIX 2

Ratings used of the Units of Assessment

The numerical rating scale applied in the Assessment is the following:

5 - Excellent
4 - Very Good
3 - Good
2 – Fair
1 – Emerging/ Weak

2.1 Scientific quality and multidisciplinary collaboration

5 Excellent International Level	The UoA's research exhibits quality that is internationally excellent in terms of originality, significance and rigour. Work at this level is able to generate significant interest within the international research community, and is suitable for publication in leading international journals or publishers with rigorous editorial standard.
4 Very Good International Level	The UoA's research work exhibits quality that is internationally recognised. Work at this level is suitable for publication in the leading international journals or publishers.
3 Good International Level	The UoA's research work is of undisputed relevance for the international academic community. Work at this level is suitable for publication in well-known international journals or by well-known international publishers.
2 Fair International Level	The UoA's research work is of possible relevance for the international academic community. Research outputs at this level is suitable for publication by international or national publishers or in well-known national journals.
1 Emerging International Level	The research outputs of the UoA include new scientific knowledge. The UoA mainly operates on a national level.

2.2 Academic impact (Impact of the research activities on the research community)

5 Excellent International Level	The UoA is internationally acknowledged as a globally leading unit in its field. The UoA is a valued partner in international research and networks, and members of the UoA frequently take part in leadership and expert tasks in the field. The UoA is highly competitive in securing external research funding.
4 Very Good International Level	The UoA is an important player in its field, and among the leading groups in its field within Europe. Members of the UoA hold potential for and take part in leadership and expert tasks in the field. The UoA participates in international research projects and networks and receives substantial external research funding.

3 Good International Level	The UoA has a solid position in the international research community as a respected and well-known centre of expertise. The UoA's impact is comparable to that of the leading groups within Scandinavia.
2 Fair International Level	The UoA is in the process of establishing its position in the international scientific community as a recognised actor in its field. The UoA's impact on the international community is irregular.
1 Emerging International Level	The UoA's publications and other research impact is aimed mainly at the national research community.

2.3 Societal impact, entrepreneurial and innovative capacity

5 Excellent International Level	The UoA is exceptionally dynamic and wide-ranging in its interaction with the society, and compares with globally leading units in the field. The UoA is a highly valued partner for corporate collaboration and entrepreneurial activities, and systematically supports innovativeness. The UoA's case studies demonstrate clear examples of significant influence on the society.
4 Very Good International Level	In international comparison within the UoA's field, cooperation between the UoA's research activities and the society provide substantial impact in terms of their reach and significance.
3 Good International Level	In international comparison within the UoA's field, the cooperation between the UoA's research activities and society is at the level expected of established academic units in the same field. The entrepreneurial and innovative capacity of the UoA is at an expected level compared to established units in the same field.
2 Fair International Level	Compared with international standards within the field of the UoA, the interaction with the society plays an undersized role in the UoA's activities. The entrepreneurial and innovative capacity of the UoA has potential to be at a higher level.
1 Emerging International Level	In comparison to other UoAs in the same field, the UoA's research activities are at a stage where it is still seeking ways to interact with the surrounding society. The entrepreneurial and innovative capacity and level of activities are low.

2.4 Research environment

5 Excellent International Level	In international comparison, the UoA offers an excellent research environment. The UoA has globally competitive capacities or combinations that make it attractive for high-class international experts in the field.
4 Very Good International Level	In international comparison, the UoA offers a functional and suitable research environment. The UoA's spearheads or combinations make it attractive at the European level for international experts in the field.
3 Good International Level	The UoA is able to offer a research environment comparable to established academic institutions in the field across the world. The

	UoA's spearheads or combinations make it attractive at the Scandinavian level for international experts in the field.
2 Fair International Level	The research environment at the UoA is still developing towards the level expected from a reputable unit in the international scientific community in the UoA's field research. The UoA's spearheads or combinations make it attractive at the national level for experts in the field.
1 Emerging International Level:	The UoA is still developing an internationally comparable research environment.

2.5 Future potential

5 Excellent International Level	The UoA has the potential to be among the University's top research and impact activities. The Panel expects that within the next 5-10 years the UoA will produce globally recognized results in its field and attract globally leading scholars and very promising doctoral students to work at the UoA. The research and technical excellence of the UoA breed and is likely to continue to breed new innovations adding value to collaborating corporate partners and societal development at large. The UoA has the potential to reach in the near future the level of excellence comparable to the most notable units in the world in the UoA's field.
4 Very Good International Level	The UoA has the potential to establish itself as a well-known and respected actor in the international scientific community in its field. Within the next 5-10 years, the UoA can be expected to have reached results that make the UoA a much-valued partner in international research networks, and to hold a solid position in the European research arena. The innovative activities are actively pursued and are likely to bring new innovations and activities adding value to collaborating corporate partners and societal development at large.
3 Good International Level	Within the next 5-10 years, the UoA has the potential to secure a position in the international scientific community as a solid performer and a trusted partner in international research networks. The UoA has capacities to be among the leading units in its field at the Scandinavian level. The UoA has a clear understanding and strategy how to develop new innovations and activities adding value to collaborating corporate partners and societal development at large.
2 Fair International Level	The UoA has the potential to be a noted actor in its field and to be a nationally leading unit. The UoA can be expected to make contributions to the activities of the international scientific community.
1 Weak	The UoA must work hard to be able to establish itself as an internationally recognised unit in its field within the near future.


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