

RAI²⁰¹⁸

**Research, Art and
Impact Assessment**

Aalto University



Aalto University

Aalto University
Research, Art and Impact Assessment RAI 2018
Report

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President's greetings

Nearly 10 years since founding – 42 international specialists assessed the development of Aalto University

In 2010, Helsinki University of Technology, the University of Art and Design, and the Helsinki School of Economics merged to form Aalto University, which was given a special national task: to strengthen the innovative capacity of Finland through first-class research, artistic activities, and education. The aim was to create a new kind of research university that combines high societal relevance with uncompromising scientific rigor and groundbreaking art.

As the first decennial celebration approached, it was an appropriate time to assess how the objectives have been achieved. Therefore, Aalto commissioned a review of its research operations, artistic activities, and level of societal impact. The assessment shows how we have succeeded in implementing our strategy for research and artistic activities, and it serves as an important tool when we start planning our new strategy for the years to come.

The accomplishments of our 26 departments were evaluated in different panels from the perspectives of the core disciplinary areas of Aalto, three multidisciplinary areas, and the innovation ecosystem. Chairs of the nine panels had the same main message: Aalto University has taken a giant leap forward in less than ten years. Praise was given to, for instance, the university's strong and internationally known brand, the tenure track system leading to further internationalization, a limited hierarchy supporting a good working atmosphere, high-quality infrastructure, cooperation with companies, and the student-led entrepreneurial ecosystem. 'Very positive sense of desire to develop Aalto to its best potential, at all levels'; 'Excellent potential for achieving broad and ambitious goals for both research excellence and societal impact', summarized the panel chairs.

The Research, Art and Impact Assessment, RAI 2018, provided Aalto University with essential information and recommendations regarding the strengths, potential, and challenges in research and artistic activities and their impact on society. The exercise acts a reference point for future research and artistic assessments of Aalto University. What is more, Aalto will use the results and recommendations of the assessment and the material collected during the process in setting goals and developing our strategy for the period beyond 2020.

Hereby, I would like to express my sincere thanks to the evaluators, stakeholders, and Aalto University personnel for investing their precious time and efforts to contribute to the successful implementation of the RAI 2018 assessment!



Ilkka Niemelä, President

RAI 2018 – Why?

To identify and assess Aalto's

- **Quality and potential**
- **Multidisciplinary collaboration**
- **Impact and innovative capacity**
- **Spearheads and emerging strengths**

To provide

- **National and international positioning**
- **Strengthening of Aalto's brand**
- **Cases and evidence of Aalto's development**

RAI 2018 – Why now?

- **Assessment of Aalto's first decade**
- **Input for the next Aalto strategy beyond 2020**
- **Input for Ministry of Education and Culture negotiations for the next period, 2020-2023**
- **Strong development of campus and innovation ecosystem**

RAI 2018 – Why?

The Research, Art and Impact Assessment carried out in 2018 is a review of the progress Aalto University has made during its initial years (2013-2017). The assessment focuses on disciplinary excellence in our core competence areas as well as on the multidisciplinary and applied fields building on the combination of fields and expertise at Aalto. Moreover, we pay attention to the societal relevance Aalto University has had in terms of local and global economic growth, wellbeing of people, or solutions to grand challenges. RAI 2018 builds on an extensive self-assessment made by the disciplinary departments as well as multidisciplinary fields, accompanied by an external view of research productivity through bibliometric analysis, and an extensive peer review conducted by 42 world-leading experts.

Under the Finnish Universities Act 2009, universities shall evaluate their education, research and artistic activities, and their impact. Universities shall take part in regular assessments of their external activities and quality systems. The assessment results should be made public. During the last eight years, we have conducted four major assessments: the Aalto Research Assessment Exercise was in 2009 during the building of Aalto University; Aalto Teaching and Education Assessment in 2011; our quality system was assessed in the Audit of Aalto University in 2016; and 2018 marks the accomplishment of Aalto Research, Art and Impact Assessment, RAI 2018.

The imperative to position Aalto University firmly as a leading international research university is the major motivation behind the current assessment exercise. An international perspective and evaluation is indispensable from the point of view of Aalto University's strategic development. The assessment is expected to play a major role in defining the new university strategy for the period running from 2020 to 2030 and beyond. The RAI 2018 exercise was a key process for Aalto University and its future.



Tuija Pulkkinen

*Vice President, Research and Innovation (2014 - August 2018),
Chair of RAI Working Group*

Aalto University Research, Art and Impact (RAI) Assessment 2018 – Executive Summary

To evaluate its development, performance, and future potential, Aalto University carried out a Research, Art and Impact Assessment in 2018. The quality of research and artistic activity, as well as the societal impact and innovative capacity, were subject to evaluation to assess Aalto's international standing and to identify fields with world-class potential.

The assessment period covered five years: from 1 January 2013 to 31 December 2017. The assessment was carried out as a peer-review process conducted by external, international, independent, and high-level experts in fields relevant to Aalto's research and artistic profile.

The experts were divided to panels based on research and artistic fields. Assessment fields 1-4 covered Aalto's four core competence areas: arts and design knowledge building, global business dynamics, ICT and digitalisation, and materials and sustainable use of natural resources. The units of assessment in fields 1-4 comprised all 26 departments of Aalto University in a mutually exclusive manner. Assessment fields 5-8 covered these integrative multidisciplinary themes: advanced energy solutions, health and wellbeing, human-centered living environments, and the innovation ecosystem.

The RAI 2018 report is comprised of the field descriptions prepared by field leaders, a short description of the departments, a bibliometric analysis, and the highlights of the assessment reports prepared by the assessment panels. The panelists assessed the units in relation to discipline and international peer groups, and not against each other.

A general observation was that Aalto University has taken a giant leap forward in less than ten years. Praise was given to, for instance, the university's strong and internationally known brand, the tenure track system leading to further internationalization, the limited hierarchy supporting a good working atmosphere, high-quality infrastructure, cooperation with companies and the student-led entrepreneurial ecosystem. Aalto's efforts in promoting multidisciplinary research were applauded in particular. The main recommendations were to:

- Clarify the role and focus of platforms
- Increase the diversity of research staff, especially the share of female scientists in technical fields
- Establish mentoring of young researchers at all career stages
- Ensure both the transparency and the speed and flexibility of the tenure track process

- Critically examine the organizational structures to support the implementation of the university's special mission, for example, the borders between different schools and departments
- Ensure both bottom-up and top-down strategic planning with clear measures of performance
- Establish external advisory boards consisting of industry representatives, alumni, and other stakeholders
- Create a comprehensive strategy for infrastructures and equipment of all sizes

A bibliometric analysis conducted by the Centre for Science and Technology Studies (CWTS, Leiden) recorded Aalto University to be a robust research organization, with overall a proper embeddedness into the international academic community. Research at Aalto is well cited: 20% over the world average, which is a sign of impact. The highest impact was observed in three research areas (Web of Science categories): multidisciplinary science (including journals like *Nature* and *Science*), management and business, and physics (multidisciplinary). On average, Aalto publishes in very high-level journals. Publications are done primarily in collaboration with foreign partners, which tends to increase the citation impact significantly. On the university level, 59% of publications were done with international partners. Aalto's research fields have a clear applied focus, and 8% of publications have industry collaborators.

A separate analysis of Aalto's future potential was made by evaluating the publication history of new professors hired since the foundation of Aalto University. This analysis demonstrated Aalto to be well equipped for the near future. The profile of new professors is not much different from the overall profile of research done at Aalto in total, while the impact of newcomers is on average at a higher level.

RAI 2018 provided Aalto University with essential information and recommendations regarding the strengths, potential, and challenges in research and artistic activities and their impacts on society. The self-assessment reports provided thorough and careful self-evaluation that will help departments in their own strategy work and to identify their future strengths. Aalto University will use all results and recommendations of the assessment, as well as the material collected during the process, in setting goals and developing Aalto University strategy for the period beyond 2020.

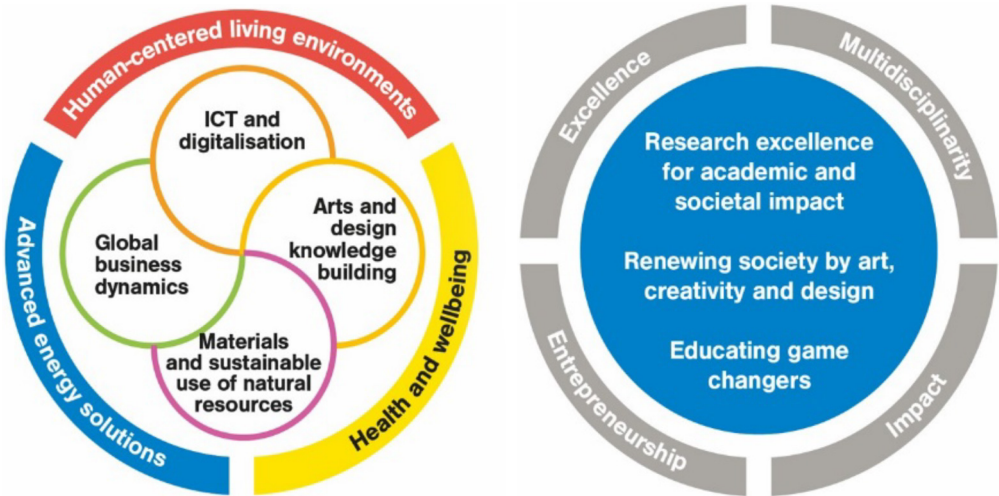


Figure 1: Left: Key research areas of Aalto University, Right: Strategy of Aalto University

Mission

Shaping the future: science and art together
with technology and business

Vision

An innovative society
Breakthrough discoveries deeply integrated with design
and business thinking enable systemic solutions and
accelerate innovation

Values

Passion for exploration
Courage to influence and excel
Freedom to be creative and critical
Responsibility to accept, care and inspire
Integrity, openness and equality

Aalto University's Mission and Strategic Development Actions

Academic excellence and societal impact

Founded in 2010 as a merger of three universities, Aalto is a new university with a unique combination of science, art, design, technology, and business. Aalto's research and education emphasizes excellence, a multidisciplinary¹ game-changing attitude, innovations, and an entrepreneurial mindset. Aalto's campus is developing to become a global innovation hub combining research-based and student-initiated entrepreneurial activities, creative industries, and industry-academia collaborations.

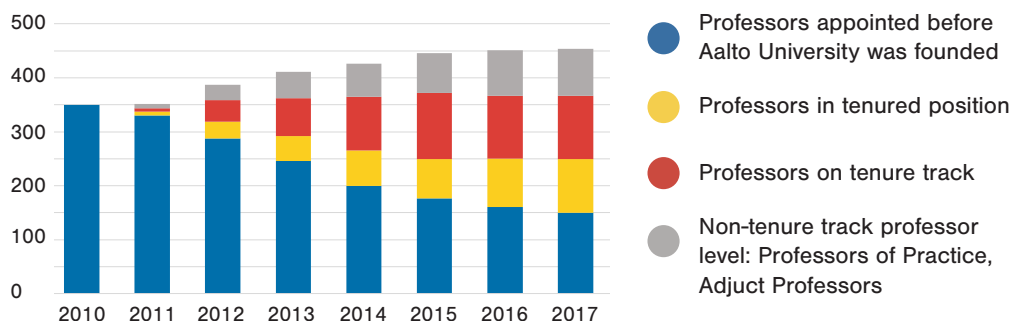
The cornerstone of Aalto University's mission is excellence in research and artistic activities. During our first eight years of operations, Aalto University's academic base has strengthened considerably. In many university rankings, Aalto University's core areas now rank globally among the top 100, and an increasing number of key profile areas are already in the top 50, led by such creative fields as art, design, and fashion in the world top 10.

With a target to reach world-class excellence in the global competition among universities, increased quality in all activities is mandatory. Aalto's strategy is to focus on selected areas of expertise and to engage in significant efforts that have potential for breakthroughs and disruptive discoveries that can contribute to Finnish industry renewal. Moreover, Aalto's unique profile building on multidisciplinary collaboration between science, art, technology, and business has already proven to be an element of attraction in itself.

Organized in six disciplinary schools, research is concentrated around seven key research areas: four core competence areas (ICT and digitalization, materials and sustainable use of natural resources, arts and design knowledge building, and global business dynamics) and three integrative multidisciplinary themes (advanced energy solutions, human-centered living environments, and health and wellbeing, see *Figure 1*). These grand challenges were selected based on their societal priority and match with our competences.

Aalto's strategy is to develop ways to combine disciplinary excellence with crossing borders into new fields and ways of working. We aim to link world-class fundamental research with efforts that develop the results to practical applications and work towards collaborative relationships with companies, public and private sector actors on campus, including shared spaces and infrastructures.

Professors at Aalto University



Professors in key research areas

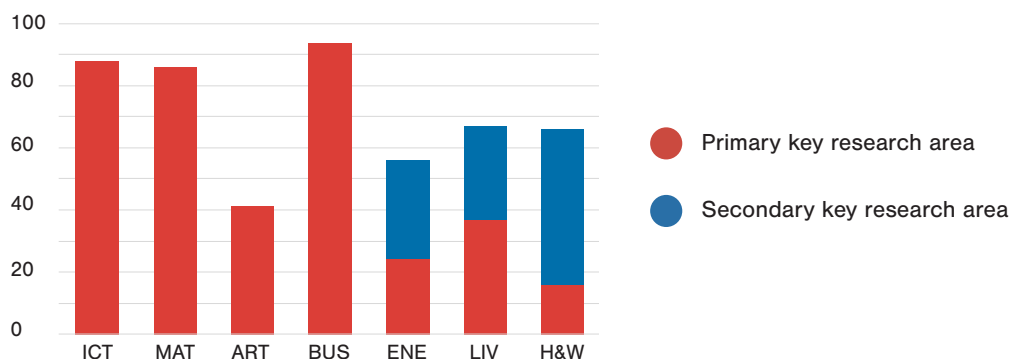


Figure 2: Top: Professors at Aalto University. Bottom: Professors in key research areas.

Tenure track professors in key research areas

Aalto was the first in Finland to implement a full-fledged tenure-track career system after it became possible under the new Universities Act (2010). The tenure track system has been a key investment in the implementation of Aalto strategy. It comprises a clear, internationally known, predictable academic career system where more junior researchers can also compete. The process is transparent and very competitive. Since 2010, we have recruited over 300 professors on the Aalto tenure track, placed in our key research areas (*Figure 2*). Aalto also offers non-tenured, professor-level positions for private sector experts who bring practical knowledge and new areas to the academic community.

Support for multidisciplinary

Multidisciplinary platforms gather people from within and outside the university to tackle multi-faceted, societally significant problems. Aalto provides resources for coordination and seed funding for initiating new activities. While researchers remain employed in their departments, everyone is welcomed to join platform activities. In addition to a forum of networks for Aalto faculty, platforms offer visibility and easy access for collaboration for stakeholders. Seven platforms are operative (Digi, Materials, Energy, Living+, Health, Entrepreneurship, Experience), and the Aalto Sustainability Hub operates much in the same spirit.

Infrastructures

Research and learning infrastructures lay the groundwork for world-class, cutting-edge research. They offer opportunities for collaboration and foster local innovation ecosystem growth. Our large infrastructures are open to all in the Aalto community, as well as external users.

Innovation ecosystem

However, traditional academic excellence is only part of Aalto University's mission. At least as important is Aalto University's societal role. The innovation ecosystem around the main campus in Otaniemi hosts Aalto students and faculty, high-tech companies like Kone, Neste, Valmet, Fortum, and Tieto, VTT and other research institutes, established entrepreneurs and startups, established entrepreneurs and startups, accelerators, and incubators. The A Grid business center hosts the Aalto Startup Center and other actors to support startups. Currently, close to 100 companies are founded every year in Aalto's ecosystem, amounting to a full 50% of startups originating from Finnish universities annually. At the same time, close collaboration with established companies continues to be a particular strength of Aalto University.

There is an unprecedented student-led entrepreneurial culture flourishing at Aalto's main campus, revolving around the Aalto Entrepreneurship Society, a student and startup community organizing over 100 events annually. Slush is a globally leading event for startups to meet investors, executives, and media; its organization involves about 2000 students every year.

The campus is not only the heart of a leading regional innovation ecosystem in Northern Europe, it is also a major node in the most innovative international networks. Corporate partnerships and European Institute of Innovation and Technology Knowledge and Innovation Communities (EIT KICs) link us with the international corporate world. The UN Technology Innovation Lab network selected Aalto's campus as its very first location, and the European Space Agency has established a business accelerator on campus. Aalto University connects the leading regional players with the global forefront.

Strategic partnerships

Aalto partners with local actors like the University of Helsinki and VTT Technical Research Centre, and such global networks as CEMS (business), Cumulus (arts), Nordic Five Tech, and the European Cluster Network (technology). Health-related Berkeley Method of Entrepreneurship, Biodesign, and Spark programs operate jointly with the University of California Berkeley and Stanford University. The Shanghai International College of Design and Innovation opened in collaboration with Tongji University in 2017. In South Korea, we have some 3 500 alumni of the Aalto Executive Education MBA programmes.

Aalto way of working

Aalto University's essence is our way of working: open and ambitious, multi-disciplinary co-creation with external partners in research, art, and education, and putting students in focus – trusting students and empowering them to take a central role in the university community. Aalto University is also the first Finnish university to sign the Sustainable Development Goals Accord and, thereby, to commit to advancing the United Nations Sustainable Development Goals as part of its teaching, research, innovation activities, and campus development.

The Aalto way of working attracts growing international recognition. In 2014, a study commissioned by Massachusetts Institute of Technology identified Aalto as one of the five emerging world leaders in the field of university-based entrepreneurial and innovation ecosystems. In 2017, Times Higher Education identified Aalto University as one of the 55 'technology challengers' that think outside the box in research collaboration and research funding, and whose novel ways of working challenge the dominance of more traditional universities. One of the flagships of the Aalto way of working, the Aalto University Design Factory, has inspired a global network of design factories extending to five continents.

Quality management

To monitor internal progress, we use the plan-do-check-act (PDCA) quality management system, including annual performance reviews followed by an agreement on university-wide actions and a four-year resource outlook. Aalto uses Ministry of Education and Culture research indicators. In 2016, the Finnish Education Evaluation Centre (FINEEC) awarded Aalto a quality label valid for six years.

Strategic objectives

- **Research excellence for academic and society impact**
- **Renewing society by art, creativity and design**
- **Educating Game Changers**
- **Transforming our campus into a unique collaboration hub**
- **Excellence in advancing and supporting core goals**

Organization and Implementation of the Assessment

Objectives of the Assessment

- To assess quality and potential of research, arts, design, and architecture.
- To assess the success of multidisciplinary collaboration within Aalto.
- To assess Aalto's research impact, artistic impact, societal impact, and innovative capacity.
- To identify leading international spearheads and emerging research strengths.
- To stimulate and encourage world-class research and artistic activities.
- To give feedback to the units of assessment.
- To position units of assessment nationally and internationally.
- To strengthen the Aalto University brand.
- To provide cases and evidence of Aalto's development.

Assessment Fields

Assessment fields 1-4 covered Aalto's four core competence areas. The units of assessment in fields 1-4 comprised all departments of Aalto University in a mutually exclusive manner, as seen in *Figure 3*. Subunits, such as research institutes, research centres, research groups or equivalent, were assessed as parts of a unit of assessment.

Field 1: Arts, design and architecture

Field 2: Business and economics

Field 3a: Chemical engineering and physics

Field 3b: Engineering

Field 4: ICT and mathematics

Assessment fields 5-7 covered integrative multidisciplinary themes. Combined in a single unit of assessment, each unit in these fields included researchers and research groups from various Aalto University schools and departments. Assessment field 8 covered the university-wide innovation ecosystem as a whole, including activities that take place outside departmental units.

Field 5: Energy

Field 6: Health and wellbeing

Field 7: Living environments

Field 8: Innovation ecosystem

Aalto University Schools and Departments

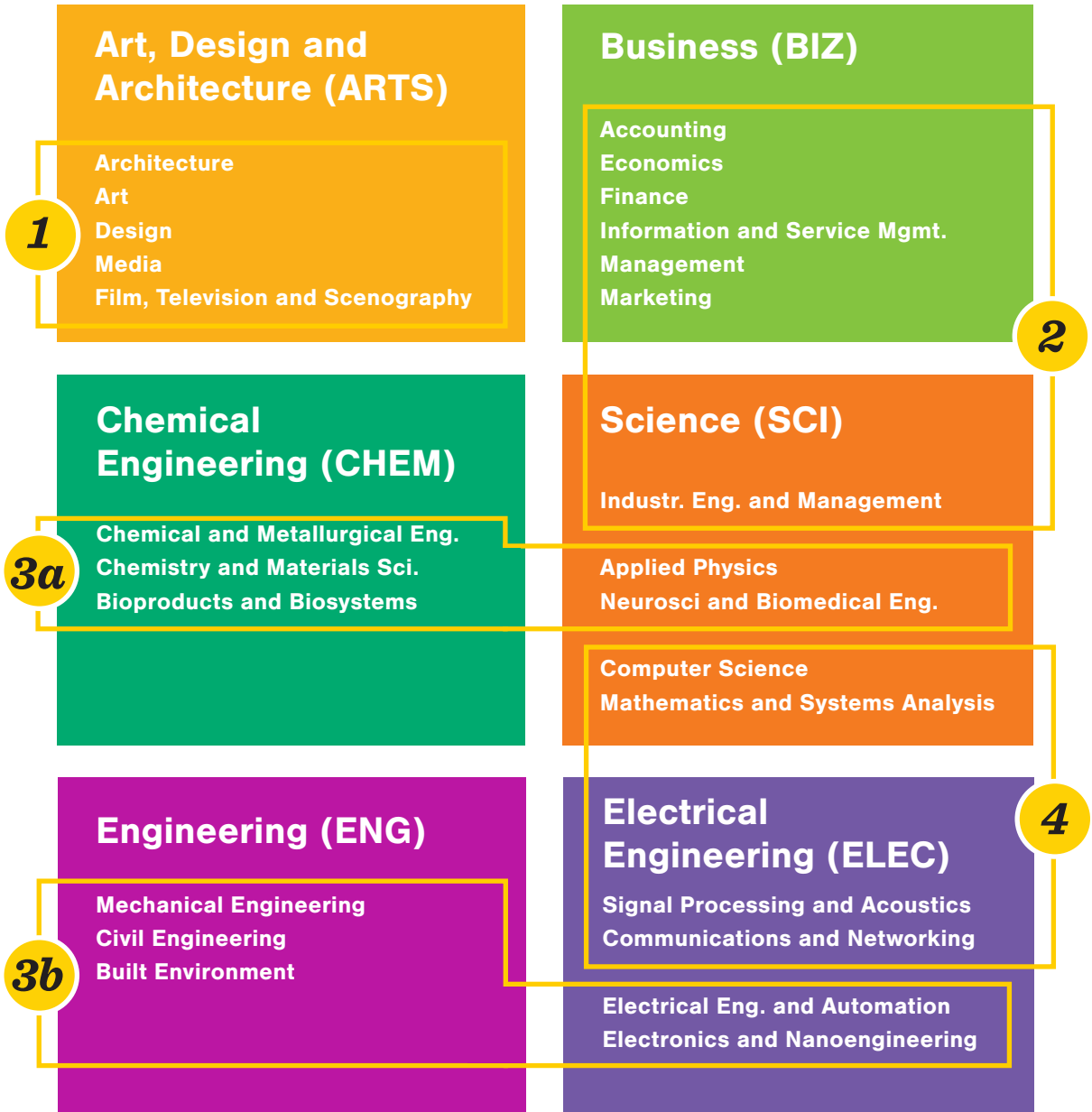


Figure 3: Aalto University's Departments in relation to RAI 2018 fields 1-4

Assessment Materials

The assessment period covered five years from 1 January 2013 to 31 December 2017, and the research, artistic, and impact results described in the assessment materials relate to this period only.

The assessment was based on written self-assessment reports, an independent bibliometric report provided by CWTS, and interviews conducted by the panels during a site visit. As supporting and background material, Aalto University strategy, selected rankings of Aalto University, and reports of significant research infrastructures were provided. In addition, the public research portal *research.aalto.fi* containing Aalto University's researchers, publications, artistic activities, and other outputs, was available.

The self-assessment reports written by the units of assessment contained evidence of the achievements during the period 2013-2017, including case studies of societal impact, bibliometric data, and other indicators of quality and impact of the research and artistic work. Most of the numerical indicators were provided by the university's information services while the units were responsible for highlighting topics most relevant for their area. In these reports, units also described their future potential taking into account any faculty renewal that has taken place.

Full assessment materials including the self-assessment reports and CWTS bibliometric report are available for Aalto University personnel at *www.aalto.fi/research-art/research-assessments*.

Assessment Organization

The President's Management Team (PMT) provided oversight and guidance while the Research and Innovation Steering Group (RISG) oversaw the assessment's execution. The RAI office, led by a project manager, was in charge of the assessment implementation. The Appendix presents the assessment organization. Finally, the staff at the units of assessment dedicated much of their time in writing the self-assessment reports and arranging site visits.

Assessment Fields and Units of Assessment

Field 1: Arts, design and architecture

- 1) Department of Architecture (ARTS)
- 2) Department of Art (ARTS)
- 3) Department of Design (ARTS)
- 4) Department of Film, Television and Scenography (ARTS)
- 5) Department of Media (ARTS)

Field 2: Business and economics

- 6) Department of Accounting (BIZ)
- 7) Department of Economics (BIZ)
- 8) Department of Finance (BIZ)
- 9) Department of Management Studies (BIZ)
- 10) Department of Marketing (BIZ)
- 11) Department of Industrial Engineering and Management (SCI)
- 12) Department of Information and Service Management (BIZ)

Field 3a: Chemical engineering and physics

- 13) Department of Applied Physics (SCI)
- 14) Department of Bioproducts and Biosystems (CHEM)
- 15) Department of Chemical and Metallurgical Engineering (CHEM)
- 16) Department of Chemistry and Materials Science (CHEM)
- 17) Department of Neuroscience and Biomedical Engineering (SCI)

Field 3b: Engineering

- 18) Department of Built Environment (ENG)
- 19) Department of Civil Engineering (ENG)
- 20) Department of Electrical Engineering and Automation (ELEC)
- 21) Department of Electronics and Nanoengineering (ELEC)
- 22) Department of Mechanical Engineering (ENG)

Field 4: ICT and mathematics

- 23) Department of Communications and Networking (ELEC)
- 24) Department of Computer Science (SCI)
- 25) Department of Mathematics and Systems Analysis (SCI)
- 26) Department of Signal Processing and Acoustics (ELEC)

Multidisciplinary fields 5-8 assessed three integrative multidisciplinary themes, and the innovation ecosystem.

Field 5: Energy

Field 6: Health and wellbeing

Field 7: Living environments

Field 8: Innovation ecosystem

The Schools are abbreviated as follows: Arts, Design and Architecture (ARTS); Business (BIZ); Chemical Engineering (CHEM); Electrical Engineering (ELEC); Engineering (ENG); Science (SCI).

Assessment Panels, Report and Criteria

Composition of the Assessment Panels

The assessment was carried out as a peer-review process. The experts were divided to panels comprising a chair and 6-10 members, who are internationally acclaimed scholars in the fields relevant for Aalto and for the assessment field, and at the same time free of conflicts of interest. For example, none of the panel members have been engaged in joint research projects or joint publications with members of the units of assessment within their panel, or were engaged in other assessments with them (e.g., as evaluator or applicant of a research proposal).

Chairs and panel members for fields 5-8 were assigned from panel members for fields 1-4. The lists of panel members are given in the Appendix.

Assessment Report

Each panel was asked to produce an assessment report consisting of field-level observations and recommendations. In fields 1-4, the assessment report also contained a separate analysis of each unit of assessment.

The panels aimed to reach consensus statements for the report, and took into account all assessment documents and interviews during site visits. Each assessment panel was expected to finish the final draft of the assessment report by the end of their site visit at Aalto University. The final assessment reports were due two weeks after the site visit.

The RAI office compiled this report of the entire assessment such that the finalized reports of the assessment panels were included in this report in shortened form. Full versions without changes to the contents of the reports are available internally within the university at www.aalto.fi/research-art/research-assessments.

Assessment Criteria

The expectations for assessment were twofold. First, each unit of assessment was compared to international standards and positioned with regard to internationally top universities or groups. Second, Aalto's success in making use of the multidisciplinary potential of its fields was assessed, with emphasis on in-house collaboration. 'You get what you measure' – the university wanted to measure excellence, societal impact, and multidisciplinaryity.

The intention was not to compare units or fields against each other within Aalto. It was considered important to use standards valid within each discipline recognizing that the fields are very different from one other.

The assessment panels were asked to present, for each unit of assessment:

- **A statement** on the research and artistic profile both in terms of comparing to international benchmarks, and in relation to Aalto University strategy and key research areas.
- **Numerical ratings** and written statements for each of the following elements (details found in the Appendix):
 - Excellence, quality, and multidisciplinary collaboration of the research and artistic activities;
 - Impact of the research and artistic activities on the research/artistic community;
 - Societal impact and the entrepreneurial and innovative capacity;
 - Strengths and weaknesses of the research and artistic environment;
 - Future potential.
- **Recommendations** for the future.

The numerical ratings were:

- 1 Emerging
- 2 Fair
- 3 Good
- 4 Very good
- 5 Excellent
- 6 Outstanding international

Panels were encouraged to use the full range of grades with grade 6 indicating exceptional quality, but yet realistic and attainable by the top units of assessment.

Utilisation of the Assessment Results

Recommendations given in RAE 2009

The Research Assessment Exercise conducted in 2009 during the formation of Aalto University highlighted the following steps as urgent for the development of the new university:

- Establishing an internationally comparable tenure-track system;
- Rapid internationalization of the research environment, with strong emphasis on international recruitment;
- Enhancing the role of long-term and high-risk basic research;
- Fostering academic leadership and long-term strategic planning;
- Requiring all professors to carry out research, including practice-based research;
- Encouraging publishing in high-impact journals and through leading international publishers.

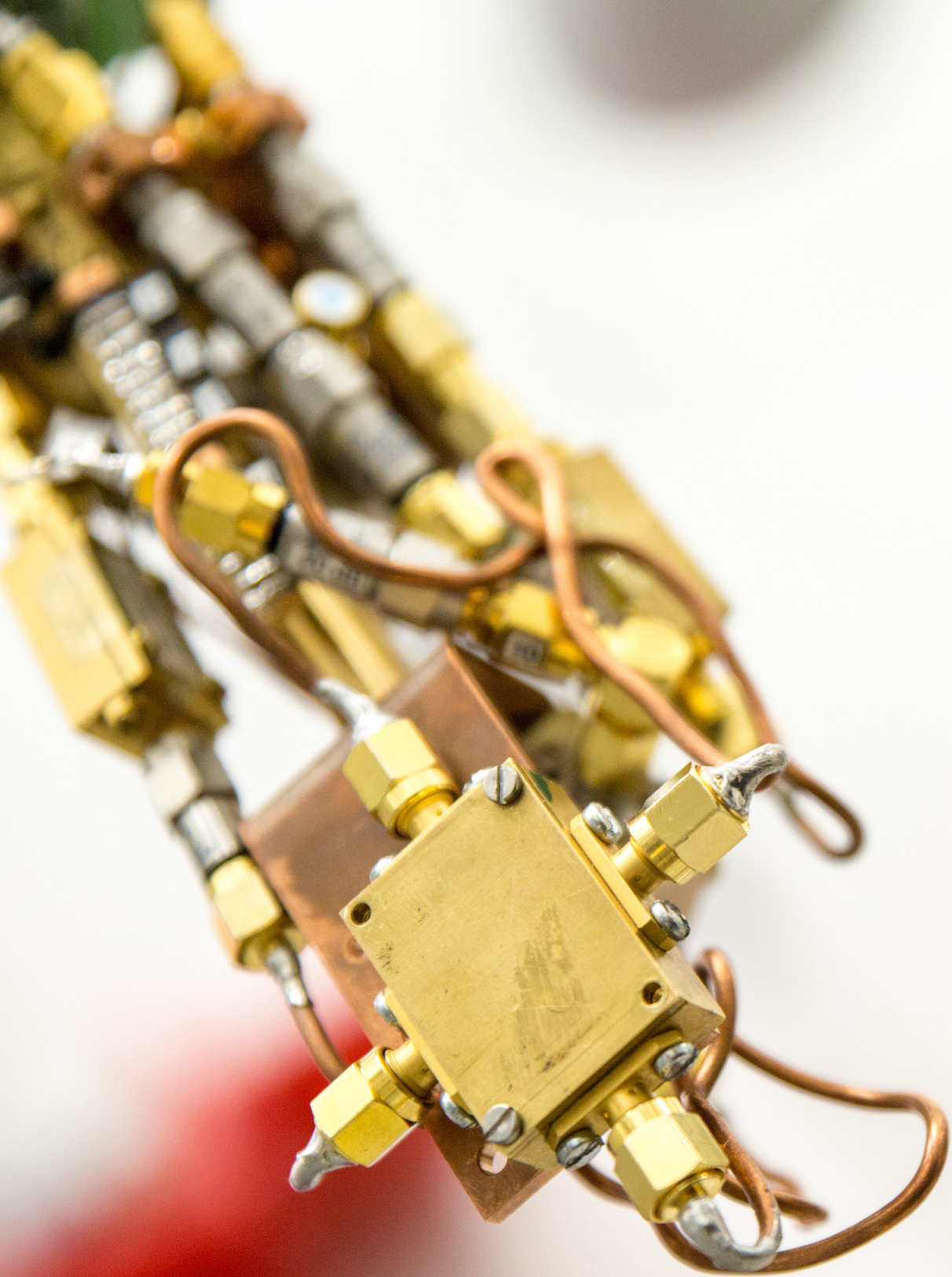
All of these recommendations have been put forward. Most notably, Aalto was the first in Finland to implement a full-fledged tenure track system and has since 2010 recruited over 300 professors to the Aalto tenure track. Approximately 37% of our academic personnel come from outside Finland, showing that international recruitment has been a successful key priority for the university.

Utilization of the results of RAI 2018

RAI 2018 provided Aalto University with essential information and recommendations regarding the strengths, potential, and challenges in research and artistic activities and their impacts on society. It was extremely useful to perform external evaluation, compare it to international state-of-the-art, and receive valuable feedback from the panels and in-house. The exercise forms a reference point for future research and artistic assessments of Aalto University.

The preparations for the evaluation forced all of Aalto and its schools and departments to identify their strengths and weaknesses. The self-assessment reports written by the units of assessment provided thorough and careful self-evaluation that will help the departments in their own strategy work and in identifying their future strengths.

No specific monetary bonuses are planned to be distributed to units in relation of their assessment results. Instead, Aalto University will use all results and recommendations of the assessment, as well as the material collected during the process, in setting goals and developing Aalto University strategy for the period beyond 2020.



Main findings and recommendations

University-level findings and recommendations

Excellent progress

The chairs of the nine panels had the same main message: Aalto University has taken a giant leap forward in less than ten years.

Praise was given to, for instance, the university's strong, internationally known brand, the tenure track system leading to further internationalisation, the limited hierarchy supporting a good working atmosphere, high-quality infrastructure, cooperation with companies, and the student-led entrepreneurial ecosystem. 'Very positive sense of desire to develop Aalto to its best potential, at all levels'; 'Excellent potential for achieving broad and ambitious goals for both research excellence and societal impact', summarized the panel chairs.

Recommendations on Multidisciplinarity

In addition to assessing the excellence and quality of research and artistic activities, the panelists were asked to specifically assess the scope and success of our multidisciplinary activities. Aalto's efforts in promoting and recognizing the importance of multidisciplinary research were applauded, and further ways to support multidisciplinary were suggested. For example, joint professorships across departments were considered worth elaborating. However, balancing between multidisciplinary focus and disciplinary research remains a question, and it was particularly observed that the BIZ School is less visible in multidisciplinary collaboration.

Platforms are one of Aalto's practical methods of bringing people together across department and school boundaries. While the aim of the assessment was not to evaluate the operations and organization of the platforms as such, several practical suggestions were received in the assessment of the multidisciplinary fields 5 Energy, 6 Health and wellbeing, and 7 Living environments, each of which has a platform supporting the collaboration and networking in the area. The role of platforms as accelerators of multidisciplinary research should be clarified and supported even more by sharpening their foci and evaluating their themes regularly. The commitment and ownership of deans might prove crucial.

The broad availability of platform seed funding was emphasized. It was suggested to find ways to secure increased university-level funding for cross-cutting themes integrating students from various levels and disciplines and solving grand challenges that Aalto can uniquely address.

Recommendations on Diversity and Mentoring

Increasing the share of female scientists and mentoring of young researchers became important targets for development. Mentoring was suggested for PhD students, postdocs, untenured tenure-track faculty (assistant professors), and international staff.

Multiple panels suggested the reinforcement of diversity and, in particular, increasing the proportion of women scientists as an important area for development. Ways to tackle the issue include: an active recruiting policy, help finding a job for the spouse of the recruit, mentoring women in technical fields, monitoring activities related to diversity, and building greater awareness of diversity issues in general.

Recommendations on Tenure Track

The tenure-track system at Aalto was broadly applauded. However, the transparency of and steps in the process and communication of the decisions were not clear in all discussions with the departments. Further, the creation of tenure-track slots could perhaps be less stringent and a bit more entrepreneurial or dynamic. It was also suggested to speed up the professor appointment process to be competitive internationally for the best talent.

Recommendations on Structures

The panels encouraged Aalto to critically examine its organizational structures, specifically the borders between different schools and departments, and to consider what organizational model would best support the implementation of the university's special mission. In some cases, reorganizing departments might help leverage shared research strengths. These suggestions were made especially regarding management studies in BIZ and SCI; between two departments in CHEM; and between several departments working on ICT in SCI and ELEC.

Other Recommendations

The panels also pointed out that the word “strategy” was seldom used in discussions with departments. There should be more bottom-up and top-down strategic planning with clear measures of performance. Aalto should empower departments to develop their own research strategies and identify the areas in which they can attain international prominence.

Establishing external advisory boards consisting of industry representatives, alumni, and other stakeholders could help in focusing research strategy, lobbying, industry collaboration, and fundraising.

Research and teaching infrastructures were in many cases found to be on an excellent level, and the atmosphere toward sharing equipment was very positive. A comprehensive strategy for infrastructures, equipment of all sizes, and research data is nevertheless needed to maintain the quality of research and artistic activities.

Bibliometric Findings

Impact 20% above world average

A bibliometric analysis conducted by CWTS covered Aalto’s publications in 2012-2016 and their citations until 2017. CWTS recorded Aalto University to be a robust research organization with overall a proper embeddedness into the international academic community. Research at Aalto is well cited, which is seen as a sign of impact. Publications are done primarily in collaboration with foreign partners. Aalto’s research fields have a clear applied focus and industry partners are often involved as co-authors.

Aalto published more than 8 500 publications (articles and reviews in journals) during the studied period of 5 years. The analysis only covers publications indexed by Web of Science (WoS). The annual volume increased about 30% during this period, up to about 2 000 in 2016. Aalto’s publications were, on average, in very high-level journals: the citation impact of these journals is 22% above world average (mean normalized journal score, MNJS). Aalto collaborates with other organizations in three out of four publications. Sixty percent of the output involves international collaboration, and on average 8% involves industry. Thus, CWTS recorded a well-integrated position of Aalto with respect to international collaboration, impact, and links to industry.

The most important impact measures show an increase over the period. On average, the impact of Aalto’s publications (mean field normalized citation score, MNCS) is around 20% above world average. The percentage of Aalto’s publications belonging to the 10% most cited in their respective fields, the proportion of highly cited publications, is similarly 20% over world average. Also, the proportion of output in collaboration with other national or international organizations increased modestly over the period. A visualization of output and impact is in *Figure 4*. The chart shows a simultaneous and gradual increase of output, impact, and impact of journals used.

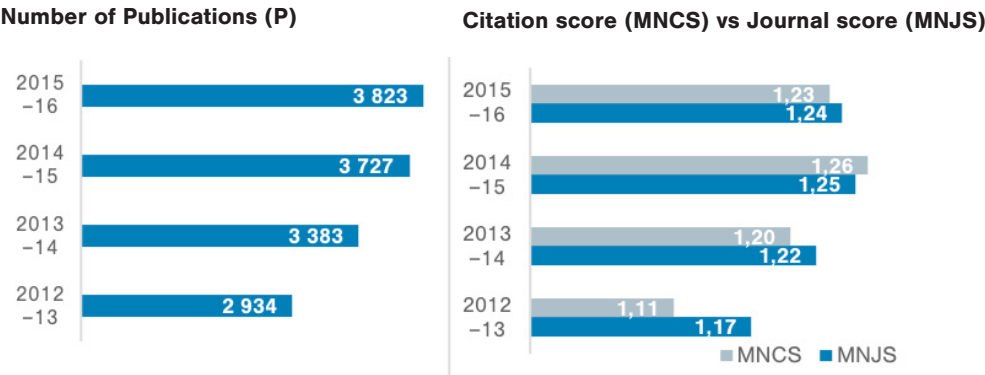


Figure 4: Development of the output and impact of Aalto University’s publications 2012-2016

Definitions of Indicators

P: Number of publications in international journals listed in the Web of Science.

MNCS: The mean field normalized citation score shows the citation impact. It relates the number of citations (without self-citations) of each publication to the average of the research area to which it belongs. A value above 1 indicates that the mean impact for the unit is above world average whereas a value below 1 indicates the opposite. Citations are counted through 2017.

MNJS: The mean field normalized journal score indicates the average citation impact of the journals in which the papers appeared. The indicator is calculated based on the same principles as the MNCS. It shows whether the publications originating from the unit of analysis were published in top or in sub-top (in terms of citation impact) journals.

PP(top10%): The proportion of highly cited publications: the proportion of publications belonging to the 10% most cited publications worldwide, in the same research area. The world average is 0.10. A unit with a PP(top10%) of 0.12 has 20% more publications in the top 10% than world average.

IC: The Internal coverage is a proxy for how well WoS covers the field in which the unit publishes, and it is based on the assumption that researchers cite relevant work. IC is calculated as an average per publication of references being covered by WoS.

Figure 4 shows the research profile of Aalto University across WoS categories. The smallest categories are omitted in the figure. Engineering and physics are the most prominent categories. In most categories, the impact is well above world average, similar to the impact of the underlying journals in which Aalto publishes. There is only one category (with more than 120 publications) in which both MNCS and MNJS are below world average, *Materials Science, Paper & Wood*. The three categories with the highest impact are: multidisciplinary, physics (multidisciplinary), and business. The large output and high impact in category multidisciplinary journals for the entire university is from researchers in the assessment field of chemical engineering and physics.

Future potential

A separate analysis of Aalto's future potential was made by evaluating the publication history (2010-2016) of new professors hired since the foundation of Aalto University, regardless of where they were working at the time of publication. This analysis demonstrated Aalto to be well equipped for the near future. The profile of new professors is not much different from the total, overall profile of research done at Aalto in 2010-2016, while the impact of newcomers is on average at a higher level (MNCS 1.65, MNJS 1.45, PP(top10%) 0.18). One should note, though, that these results are calculated for professors, whereas Aalto's figures in general contain publications of all staff members.

Research profile

WOS category	P	MNCS	MNJS
ENG,ELEC&ELECTR	534	1,07	1,16
PHYSICS,APPLIED	368	1,05	1,06
PHYSICS,COND MAT	354	1,04	1,01
MATER SC,MULTID	352	1,27	1,35
MULTIDISCIPL SC	301	2,48	2,10
CHEM,PHYSICAL	281	1,03	1,17
ASTRON&ASTROPH	271	1,11	1,11
PHYSICS,MULTIDIS	257	2,23	2,15
MANAGEMENT	200	1,28	1,28
ENG,CHEMICAL	190	0,96	1,15
TELECOMMUNICATIO	181	1,04	1,19
CHEM,MULTIDISC	178	1,16	1,49
OPTICS	168	1,04	1,07
ENERGY&FUELS	155	1,46	1,36
NEUROSCIENCES	149	1,37	1,30
BUSINESS	142	1,69	1,49
MATER SC,PAPER&W	140	0,64	0,70
POLYMER SCIENCE	137	1,10	1,12
MATHEMATICS	131	1,19	1,18
COMP SC,AI	131	1,26	1,31
PHYSICS,FLUID&PL	124	1,28	1,17

Figure 5: Research profile and impact of Aalto University over Web of Science categories
P: Number of publications, MNCS: The mean field normalized citation score, MNJS: The mean field normalized journal score

Collaboration

	P	MNCS	MNJS
Intl collab	5037	1,42	1,35
Nat collab	1534	1,00	1,09

Figure 6: Number (P), impact of publications (MNCS) and impact of journals (MNJS) of Aalto University's publications done in international or national collaboration

International collaboration and industry collaboration

The majority of publications at Aalto is done in international collaboration, and *Figure 7* shows the top departments in this respect. The impact of these publications (MNCS) is considerably higher than others, and similarly the journals in which Aalto publishes in international collaboration have higher impact (MNJS), as seen in *Figure 6*.

The amount of industrial collaboration was also analyzed. While the average percentage of publications with industry representatives is 8%, some departments score significantly higher, as seen in *Figure 8*. In technical disciplines, Aalto University’s benchmark universities are Delft University of Technology (Netherlands) and the Technical University of Denmark (DTU), both having 11% publications co-authored by industrial representatives.

Top international collaboration			
Aalto level	59%	Dept. of Applied Physics (SCI)	72%
Dept. of Electronics and Nanoengineering (ELEC)	68%	Dept. of Marketing	65%
Dept. of Finance	65%	Dept. of Computer Science (SCI)	64%

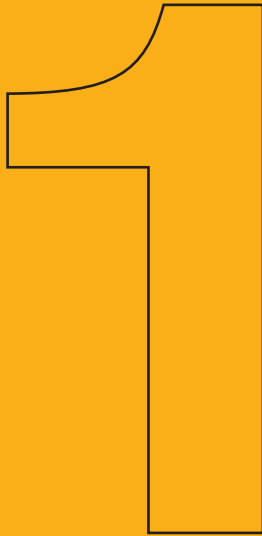
Figure 7: Top international collaboration by share of co-authored publications

Top industrial collaboration by share of publications (Aalto level 8%)			
Dept. of Communications and Networking (ELEC)	16%	Dept. of Electrical Engineering and Automation (ELEC)	11%
Dept. of Bioproducts and Biosystems (CHEM)	14%	Dept. of Electronics and Nanoengineering (ELEC)	11%
Dept. of Signal Processing and Acoustics	12%	Dept. of Mechanical Engineering	11%

Figure 8: Industrial collaboration in publications

Varying internal coverage

In subsequent chapters, the field-level bibliometric summaries are shown. In some departments, the number of WoS publications is very low: researchers may publish their results in media other than WoS-indexed journals or even in a totally different manner. It might also be that WoS does not adequately cover the research field. This is measured by internal coverage (IC). It considers the list of references in a publication, whether they are indexed in WoS or not. IC is the average proportion of references in the analyzed publications that are found in WoS. In some departments, the publications mostly refer to publications not found in WoS. Care must thus be taken when interpreting the bibliometric figures in these cases.



Field: 1
Arts, Design and Architecture

***Paul Seawright, Chair;** Peggy Deamer; Paul Gough;
Kees Dorst; Manuel Damásio; Susan Kozel.*

Field Description

At Aalto University, we believe that to address major societal changes we need systematic solutions that build on user-centric approaches and new, value-generating models. Successful universities in this era will not be those who replicate old practices but will be the ones who dare to explore and experiment in new, creative ways. Within Aalto, we have great opportunities to be at the forefront of future development by building a truly excellent, genuinely creative, and multidisciplinary university that is well integrated in societal and economic development.

We want to renew society by art, creativity, and design. These concepts radically question and challenge our society and culture. They generate new knowledge and understanding, and create value by leveraging humane designs and viable solutions.

At Aalto University, the fields of art, design, and architecture are covered by the School of Arts, Design and Architecture (ARTS). Today's Aalto ARTS was formed on 1 January 2012 when the former School of Art and Design and the Department of Architecture from the School of Engineering merged. ARTS is the largest school of its kind in Nordic countries with 457 employees and 2 741 students (2017). In QS University Ranking by subject 2018, Aalto was in the top 10 in the field of art and design, and in the top 50 in architecture and built environment.

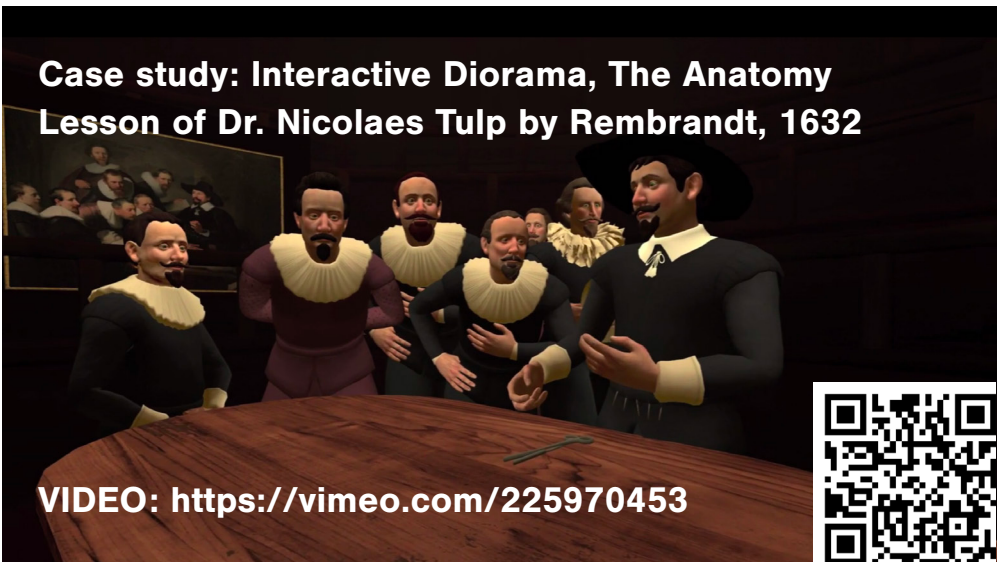
Aalto ARTS offers higher education in five departments: Architecture, Art, Design, Film & Television & Scenography, and Media. Most art and design schools do not have these five areas side-by-side. ARTS is also exceptional as an environment: we are part of a university where art, design, and architecture are combined with science, technology, and business. Multidisciplinarity is thus our strength and spirit.



Shaping the Future

Aalto University School of Arts, Design and Architecture (ARTS) is building our future with a focus on fostering a more innovative society. Through ARTS, we gain insight into our past and the present, and we approach development from another perspective. We embrace imaginative, compassionate, and unconventional approaches to deal with the most pressing challenges facing the world today. Through collaboration, we look to move beyond academic silos, bridging the fields of art, technology, and business to successfully forge new solutions.

Case study: Interactive Diorama, The Anatomy Lesson of Dr. Nicolaes Tulp by Rembrandt, 1632



VIDEO: <https://vimeo.com/225970453>

ARTS has a wide impact on society

Strong international networks and connections allow ARTS to develop its future impact on society on a global level with an interdisciplinary approach. At the same time, as seen in the self-assessments of ARTS's five departments, field-specific excellence is identified and cherished throughout ARTS, and the departments cooperate extensively with institutions and networks in their fields.

Research, education, and creative practices in ARTS are carried out in close collaboration with national, municipal, cultural, and professional institutions and companies. Today arts, design, and architecture are at the core of creative economies. The fourteen case studies reported by our five departments show a wide range of customer-centred business models, service design, and branding competence, as well as artistic achievements that have powerfully impacted the global fashion world and professional art markets, for example. At the same time, research and artistic activities at ARTS are deeply involved in sustainable design and architecture, the development of art education in primary schools, and answering the challenges of health and wellbeing in an ageing society. These case studies are evidence of our long-term partnerships established with private and public institutions in Finland and abroad.

Internationally recognised research

Excellence in research has been a long-term strategic goal of ARTS. It can be attained by recruiting people who are able to integrate hands-on creativity and critical academic discourse. It also requires forming strong, professor-led research groups and research consortia with researchers from other fields at Aalto. Examples include the ERC Consolidator Grant Prof. Paula Hohti received in 2017 to investigate the meaning and spread of western fashion in 17th century Europe, and the consortia with Aalto's School of Chemical Technology during the project *Design-driven World of Cellulose*. ARTS also plays an active role in Aalto platforms, and it has hosted a series of important international conferences discussing practice-led and artistic research (e.g., Art of Research and Photomedia).

Table 1: Number of artistic outputs (Source: ACRIS database)

	2013	2014	2015	2016	2017
Domestic	136	166	149	181	116
International	89	92	138	135	151
Total	225	258	287	316	267

Doctoral programme. ARTS has a joint programme for all doctoral candidates in different research fields. Doctoral candidates are an important part of research groups, and also co-authors of many publications. ARTS is a forerunner in encouraging art-based or design-led dissertations, and dissertations for the Doctor of Arts degree¹ can include artistic or design productions. Nearly 20% of the 180 dissertations accepted during 1991–2017 contain separately pre-examined artistic components. If we include those with submersed art or design components, this increases to 35%. During 2013–2017, a total of 85 dissertations have been approved.

Aalto ARTS Books. For strategic purposes, ARTS has its own publishing house. It annually publishes 30–40 books of high visual quality and content both in academic and the non-fiction fields, aimed at professionals or a wider audience. Aalto ARTS Books has the right to use the peer-review label, and in 2017 it rose to level 1 in the Finnish publication forum ranking JUFO. Aalto ARTS Books is globally active and has also produced books in cooperation with established publishers, such as the Victoria and Albert Museum, Intellect, and the University of Applied Arts Vienna. All publications are available internationally on the Aalto web shop and via the Dutch distributor Idea Books.

Renewing society through art, creativity, and design. ARTS encourages personal expression, intellectual curiosity, and critical thinking, and art and creative practices underscore all its professional and academic activities. At Aalto, faculty develop their academic field, through research or through their artistic activities (or both). In 2010, ARTS started to develop indicators of artistic excellence to provide benchmarking information and to have artistic achievements acknowledged in the allocation of quality-related funding within multidisciplinary Aalto. As of 2016, the main criteria of significance have been artistic forums, where the outputs received prizes or were exhibited or otherwise published, thus 'peer reviewed'. For this purpose, a list of TOP10% forums has been made for each field, and the lists are revised annually. Both in 2016 and 2017, 26% reached the TOP10% categories.

The multiple national and international prizes received by ARTS students and faculty are evidence of the quality of our artistic outputs, as shown at major international forums, such as the Milan Furniture Fair, Venice Biennale, Hyères Fashion Festival, Paris Photo, and numerous film festivals.

¹ It is customary in Finland to have different names for doctoral degrees in different research fields. In architecture, a graduated doctor is called Doctor of Science (architecture), and in art and design, Doctor of Arts (art and design), abbreviated DSc and DA, respectively. The degrees are comparable to the PhD degree, and for clarity's sake PhD is often used in English translations.

Within Aalto, the Dean of ARTS is also the Vice President of Art and Creative Practices at the university. ARTS has had a strong influence and willingness to promote university-wide activities, such as University-Wide Arts Studies (open to all Aalto students), and the new Experience Platform (established in 2017). Aalto Studios makes unique facilities available for creative industries and the use of technological innovations to fulfil artistic needs that also serve the digital society at large.

Future potential

Following Aalto's strategy and the recommendations of Scientific and Artistic Advisory Board's reports, ARTS made a Strategy Implementation Plan in 2016. The description of Field 1 follows its alignments. The plan has been updated yearly with concrete next steps for the year to follow. In autumn 2018, when the move to the new Väre building is completed, we will continue piloting new ways of working and make good use of new possibilities for cooperation between departments, students, faculty, and service personnel. We can then also further increase transdisciplinary collaboration with other Aalto schools. By the end of 2022, Aalto Studios will open its doors next to Väre on the Otaniemi campus.

The future potential of Aalto University, and especially the field of arts, design, and architecture, lie strongly in the expansion of creative fields. The creative industry is growing quickly, both nationally and globally. It makes a significant contribution to other fields and helps to find solutions to societal and economic challenges through, for example, human-centric and user-inspired design, as well as collaboration and co-creation. By further investing in arts and creative fields in Finland and in the Aalto ecosystem, and by greater utilisation of creative competence, diversification of the economic structure can be accelerated, exports can be promoted, and the added value of production can be increased. This is grounded in the fundamental role of art as a creative social practice that shapes perceptions of the world. It creates and mediates meaning by allowing practitioners, participants, and viewers to critically reflect on, and respond to, the past, present, and future. Art as human capital and capacity is the core value in all ARTS activities, which allows for new ways of thinking and approaches to emerge in all our fields and beyond.

The Aalto ecosystem has great opportunities to lead in Northern Europe and a significant player at the global scale – not only in innovation but also in creativity.

Research profile

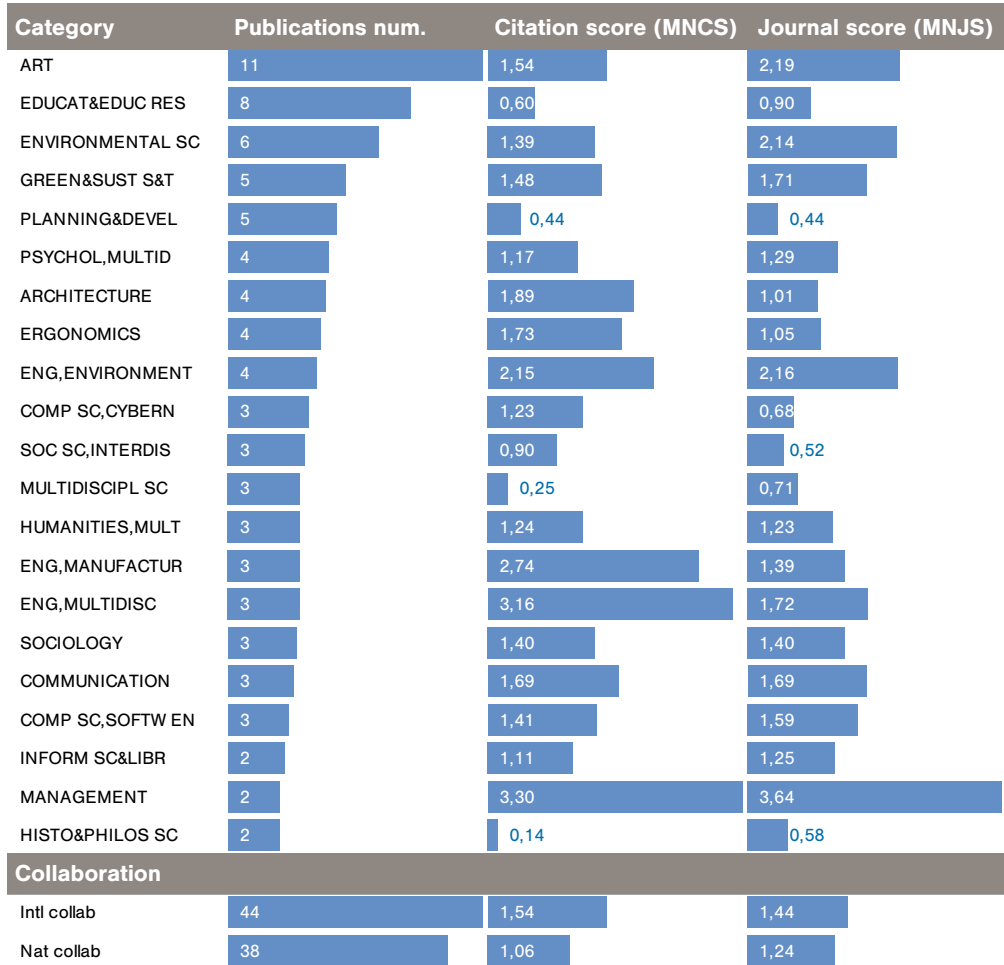


Figure 9: Research and Collaboration profile (output and impact) Field 1 – Arts, design & architecture, 2012-2016

Bibliometric analysis

International experts, such as ARTS's Scientific and Artistic Advisory Board, have noted the wide range of ARTS research, including a significant output of books, articles, dissertations, and conference papers, and a clear trend is to publish in high-indexed journals. For Leiden University CWTS, however, the main source of its bibliometric analysis for this Aalto RAI assessment was the Web of Science (WoS) database, in which many important art and design journals are not included. Therefore, only 125 papers were included in the analysis, and the IC was under 50%. According to Aalto statistics, Field1/ARTS published 420 peer-reviewed articles in international journals during 2013-2017, and since CWTS analysed 125 WoS papers, the IC is only 30%. Taking into account books, conference papers, and non-peer-reviewed articles, the total number of publications is 1317, and coverage is only 9%.

Fortunately Finland, following other Nordic countries, has established a more extensive publication ranking system called JUFO². The increase in JUFO scores from 123 in 2010 to 365 in 2017 is remarkable. Research in arts, design, and architecture is traditionally not well covered by the Web of Science (WoS). Researchers in these disciplines and areas tend to publish their output in other media or even in a completely different way. The CWTS Bibliometric report on the performance of this Aalto Field need to be treated with great care and caution.

Table 2: ARTS peer-reviewed articles in scientific journals and other scientific publications 2013-2017. (Source ACRIS database)

	2013	2014	2015	2016	2017
Peer-reviewed	53	82	81	110	94
Other	230	205	171	139	152
Total	283	287	252	249	246

	2010	2011	2012	2013	2014	2015	2016	2017
JUFO Score	122,7	158,3	179,0	154,4	233,7	199,3	329,5	364,6

² JUFO (a Finnish abbreviation for Publication Forum) is a Finnish rating and classification system for academic journals, conferences and book publishers. The system uses the following ratings: 1 = basic level, 2 = leading level, 3 = highest level. Checked publications but not ranked = 0. The evaluation is performed by discipline-specific expert panels. For a JUFO score, each publication is awarded a number of points based on the JUFO level.

Table 3: Overview performance (output and impact)

	Publication number	Mean normalized journal score (MNJS)	Internal coverage (IC)	Mean field normalized citation score (MNCS)	Portion of highly cited Publications pp (top10%)	Portion of Publications pp (collab)	Portion of Publications pp (intl collab)	Portion of Publications pp (industry)
2012-2016	125	1.32	0.40	1.32	0.13	0.66	0.35	0.04
2012-2013	29	0.92	0.45	0.87	0.10	0.66	0.31	0.03
2013-2014	44	1.68	0.36	1.79	0.20	0.61	0.32	0.05
2014-2015	61	1.69	0.37	1.68	0.16	0.62	0.34	0.03
2015-2016	63	1.10	0.40	1.12	0.08	0.65	0.37	0.03

The first result to consider is IC. In this field case, it is rather low (0.40). Hence, approximately 60% of similar relevant output is not covered by WoS. Thus, the 125 publications covered represent less than half the output of Field 1. Still, these publications are in high-impact journals. Due to low numbers each year, the MNJS fluctuates but is always around or well above world average. Also, the impact of this output is well above world average and correlates strongly with the MNJS. The PP (top10%) score is, in the most recent period, somewhat lower than the MNCS would predict, which means that the impact as measured by MNCS is skewed. A few papers with high impact are responsible for the higher MNCS.

Furthermore, the output has increased significantly: it has more than doubled. This increase did not lead to an increased WoS coverage. We, therefore, assume that the increased production has been both within WoS journals as elsewhere. Another typical characteristic of this field is international collaboration. We note a lower percentage here than, for instance, for the entire university. This is likely due to our locally oriented research in this field. Finally, the proportion of output in collaboration with industry is below the proportion of the entire university. A proportion around 0.04 is not unusual in these particular disciplines and areas.

The research profile of this field shows low numbers or publications per journal category but a clear focus on art. Another notable outcome is that both Environmental Science and Green & Sustainable S&T are among the top categories. This may relate to collaboration within Aalto's strategic multidisciplinary initiatives.

The overview also demonstrates that the few already-mentioned high impact publications are most likely in Multidisciplinary Engineering and Management. The collaboration profile of Field 1 shows a similar output for each type. The MNCS and MNJS are highest for output involving international collaboration.

Panel's Field Assessment

The achievements in the first 8 years are impressive, and the consolidation on a single campus and the institutional support for multidisciplinary provide an exciting platform for moving forward. However, the field (Departments) do not yet have a coherent or convincing vision (beyond maintaining areas of strength and pursuing multidisciplinary research) and are at risk of losing ground in a global context. The subjects encompassed by this field are facing a tidal wave of change and transdisciplinary opportunity. Aalto will lose its global position if it does not respond quickly and strategically. That will require a degree of change, focus, and leadership at every level over the next 5 years. Key to the success of the field, and more widely the multidisciplinary strategy at Aalto, is strategic leadership and facilitation embodied in the recently created Vice President of Art and Creative Practices. The field is well positioned to capitalise on recent progress with joint professorships, cross-school thematic multidisciplinary research funding success, and subsequent world-leading publications and impact; but it will benefit further from facilitative senior leadership across the institution.

The subjects in this field have been emerging as key components in national industrial and productivity strategies across Europe and, more recently, Asia. They recognise the economic and cultural impact of the creative industries. In the UK, they are the fastest growing sector of the economy contributing £92 billion of GVA; three times the GVA of the automotive industry, six times as much as life sciences, and nearly ten times that of aerospace. Much of that growth is delivered through the industries that map to Field 1 at Aalto. They encompass the broadly defined screen industries including film, games, animation, interaction design, sound, VFX, photography, media, visual communication, digital art, product design, VR/AR and their application in many contexts, including health, business, heritage and museums, engineering, architecture, planning, et cetera. This presents the field with unprecedented challenges and opportunities but confirms that Aalto is perfectly situated to capitalise and contribute to the development and growth of the region's creative economy.

Recommendations on Development of the Field

We commend the research, values attitudes, and strategic potential of the School of Art, Design and Architecture. It is clear from the evidence and the series of meetings that it commands an enviable position as a leader in art and design education, and the Aalto brand is recognised widely in global creative industries.

The school has successfully developed the quality and reach of its research and is publishing in the best fora in the field with a notable impact on the development

of the field in a range of subjects. The tripling of the JUFO score in the census period is impressive and is proof of the deep investment the school has made in creating high-quality research outputs and developing a research environment that nourishes the highest endeavours. The school has ubiquitous engagement with society and demonstrates clear evidence of its influence in the case study examples. They are a highly valued research partner internationally, within and beyond the academy. The balance of scientific research and artistic and/or practice-based research is appropriate. Many other benchmark universities in Europe have a more inclusive and integrated definition of research in relation to artistic practice and have been developing a discourse of research around (and through) practice. Other countries have been successful in articulating artistic research methods and forms of publication that are well recognised by research councils and government. Aalto is in a leading position to lead that debate in Finland. However, the RAI has not presented a hierarchy in this regard, and some of the most impactful and outstanding international research activity is in the area of artistic practice (Fashion, Photography, Contemporary Art). Without these, the field and school would be greatly diminished, and we encourage continuity in how internal funding instruments, professorial appointments, and tenure and promotion opportunities continue to equally recognise all forms of research and practice, however conceived or disseminated.

Multidisciplinary Research

The multidisciplinary ecosystem in the school has matured and all staff regard themselves (in particular, newly appointed staff) as interdisciplinary researchers. The joint professorships are, in most cases, delivering or have the potential to deliver outstanding research, opening new fields and opportunities for publication and impact at the highest level. Some cross-school strategic multidisciplinary projects may need to be incentivised or shaped from the leadership level to meet aspects of the strategic plan.

Investment

The significant investment in the new school building and bespoke workshop environments, Aalto Studio plans, tenure track expansion, targeted recruitment of international researchers for professorships, and university support for artistic and creative research provide an enviable platform for the ARTS. This enables the school to address major societal challenges, collaborate extensively with national and international partners, be the reference point for design and art education in Finland, and publish conventional research in high-index journals. Undoubtedly, the research environment is world-leading and provides the ideal platform for maintaining global leadership.

Although the Department of Media appears in the holistic scoring to be an outlier, it remains of strategic importance to the school; it is clear that there is room to review the range of activities they are currently undertaking, the spread and fit of sub-disciplines within the area, and the opportunity to achieve greater focus in the research they wish to pursue. This is so considering how its areas of focus are intertwined with potential areas of future development for the school's research. Future investment should also be channeled to the definition of how this potential can be explored via new organizational arrangements.

Leadership

Some departments would benefit from a clearer, longer-term vision and direction that takes a forward look of at least five years. This may be an issue of research leadership, and we were not convinced that the current operation of research and department heads is sufficiently strategic, particularly horizontal engagement across the school and the seizing of multidisciplinary potential across different disciplines. For the school to continue to compete at the highest level (and compete more consistently for EU competitive funding), it will need to be more interventionist in relation to research strategy, planning, research groups, projects, and programmes. There may be a need for greater focus, and for decelerating some activities and purposefully growing others. Strong leadership will be essential in reaching these long-term and impactful decisions. Ideally, this should be led from the top (VP level) and from the bottom (department research heads and department heads) with a clear articulation and communication of the strategy.

Structure

Does the current governance structure encourage sufficient cross-school collaboration to compete internationally? We recommend looking not just at co-location in Väre as a solution but consider how the integration of doctoral and research programmes might respond more aggressively to opportunities presented by collapsing subject and discipline boundaries, particularly in digital and screen related media. We qualify that recommendation by acknowledging the need for stability following a significant period of organizational change.

Joint Strategic Initiatives

The panel recognise the impact of University-Wide Arts Studies (UWAS) across the university. We recommend that the university establish a stable situation for UWAS (and other joint strategic initiatives) integrating it fully across Aalto and using it to as a pathway to initiate multidisciplinary dialogue and promote wider engagement with creative and practice-based methodologies. There is an opportunity to deepen the research as it relates to cross-university

pedagogy: UWAS will be enriched by further systematic enquiry and engaged research.

Mentoring

The panel recognised the informal processes in place but strongly recommends a coherent mentorship and research induction programme to support international staff on appointment, along with a programme of professional development and continued research support for faculty and doctoral students.

Professors

The balance of tenure-track professors and professors of artistic practice (PAP) is uneven across the field. The PAP designation has been instrumental in the success of both teaching and research. The permanency of the position within the department, combined with the 5-year rotation of the post holder, recognises the particular practice dimensions of the field. Care should be taken to ensure all departments have an appropriate mix that reflects the balance of practice and conventional research activity. The joint professorships have had an enormous impact, and whilst these can be challenging from a management perspective, they have been central to the multidisciplinary agenda. Joint professorships in interaction design, animation, games, sound/virtual reality and CHEMARTS reflect this ambition, and we would support this approach in relation to other key areas.

Aalto Studios

Develop a clear strategy for Aalto Studios and a model for department access and engagement. It is presented as a game changer by various departments without any concrete sense of the research or specific fields that might benefit or targeted opportunities for collaborative research. It is imperative that the Studios do not become a university-wide service facility to support teaching but are planned to deliver research innovation, and industry and international collaboration.

Department of Architecture

Description of the unit

The Department of Architecture combines Finnish architectural traditions and experiences with global cultures and creative solutions. The strength of the department is the close integration of the academic community with professional practitioners in the fields of architecture and construction, municipal government, and national institutions, as well as a wide international network. The department has three degree programmes: architecture, landscape architecture, and interior architecture (from 2018). Doctoral education in architecture, landscape and urbanism is given in the common doctoral programme by the School of Arts, Design and Architecture (ARTS). The activities of the faculty are organized in five focus groups: BASE: Principles, theory and history of architecture, building design; SPACE: Urban planning and design, housing design; SMART: Building technology, design of structures, wood architecture; LAND: Landscape planning, management, and design; GROUP X: Emergent design methodologies. The faculty represents leading practitioners with active careers, as well as academic scholars in all the fields of architectural research.

Highlights of the panel assessment of the unit

The Department of Architecture has successfully positioned itself as a national and international leader in architecture and urbanism. In scale, ambition, and standing, it is recognised as an international leader in practice-based enquiry, research, and professional practice. Landscape architecture has yet to assert itself and interior architecture is about to start. When these programmes gain confidence and push architecture to move beyond its traditional hegemony, the programme will only get stronger.

There are numerous excellent, research-driven projects in the DoArch that acknowledge a changing field - one that is moving from object-production to networked, performative, and service-driven. The three case studies presented to the panel demonstrate the advantages of cross-disciplinary research and its strong impact on cities and public spaces; this is also characteristic of the other humanitarian-led projects, such as WiT LAB projects and the Wood Program. These projects indicate exceptional awareness of new, 21st-century demands and the need to marshal research to meet these challenges. This awareness makes the department a model in redefining architectural design to include procurement and performance, buildings and urban systems, and legislation and enactment. There are few other architectural schools capable of embracing this new direction so emphatically.

Department of Art

Description of the unit

The Department of Art (DoArt) educates and prepares professionals in the fields of art education, visual culture, curating, and contemporary art. DoArt is recognized nationally and internationally for high-quality artistic and art pedagogical activities, scholarship, and research. DoArt has three study programs: art education (BA and MA degrees), Nordic visual studies and art education (NoVA, MA degree), and visual cultures, curating and contemporary art (MA). DoArt houses the Centre for General Studies (YoYo) that provides general art and theory studies for all students at the school of ARTS. Moreover, the department plays a key role in University-Wide Art Studies (UWAS), a strategic joint initiative that offers all Aalto students and faculty an opportunity to explore art-based practices and processes beyond disciplinary boundaries. Our students, faculty, and postdoctoral researchers constitute a dynamic artist and researcher community with a strong societal impact through art, visual culture, curating, and pedagogy.

Highlights of the panel assessment of the unit

The research undertaken in the in the Department of Art is strongly aligned with the university's history, values, and ambitions; it is well informed, highly strategic, and addresses global grand challenges with imagination and innovation. 'Display', socially engaged practice, and critical activism is at the conceptual heart of the contemporary art practice. Art education research is a national game changer and demonstrates the highest level of innovation, engagement, and impact. It is recognised as a global leader in the teaching of arts education.

Across the department, research is at an outstanding international level, comparable to the best international units in the same field, demonstrating high levels of innovation and acting as primary points of reference in the field.

Research in the department generates significant interest within national and international research and artistic communities; and it has been shared at the Venice Biennale and curated for major events in Sao Paulo and other global venues.

Of national significance is the fact that the department has educated, for over 100 years, teachers in Finland in the visual art education (VAE) programmes. The department is the leader in this field, drawing effectively from its research projects and working actively with educators in schools, museums, and other pedagogical institutions; the staff and alumni organize events and participate in policy-making and national-level curricular work. The department makes a huge impact on the visual arts education in the country, leading and setting an international standard.

Department of Design

Description of the unit

The Aalto ARTS Department of Design (DoD) is a community of creative, proficient, and thoughtful designers. The department embraces practical design skills, artistic exploration, and the societal worth of design. We educate professionals and visionaries for established and emerging design arenas. The department provides expertise, support, and facilities for ambitious design achievements. DoD is committed to success, sustainability, and social justice. DoD focuses on collaborative design, sustainable design, and practice-led design research. Our education covers a range of design practices, including product design, industrial design, service design, co-design, interaction design, fashion and clothing design, textile design, colour and material design, craft design, sustainable design, design management, and design for governance.

Highlights of the panel assessment of the unit

The DoD performance over 2013-2017 has been outstanding, with a strong growth in research quality over the period under consideration. The research now reaches the peer-reviewed venues where one would expect it to be published and is rightly valued and widely quoted in the design research community. This is quite an achievement for a small department that, from a teaching perspective, needs to cover a wide array of design disciplines that are each very broad in themselves.

The DoD encompasses quite conventional design disciplines as well as new, emerging ones. The traditional strength of Aalto design and Finnish design is augmented by new disciplines/approaches, like human centered design, service design, co-creation methodologies and emphatic design (and Aalto has played a very active role in developing these new branches to the tree of design professions).

The DoD has a very clear strength in its unique, high-quality network with peer academic institutions around the world, and it is a valued active initiator/contributor to projects internationally. But this may not always translate back into the development of cutting-edge education and research at the department. To be in step with developments internationally, the department will need to grow its research capacity substantially, focus on key areas where it can claim to be world-leading, and build up a much stronger and more specific mission.

Department of Film, Television and Scenography

Description of the unit

The Department of Film, Television and Scenography (DoF) is a vital combination of innovative art academy and an active, practice-based, and artistic research unit. It teaches all aspects of filmmaking and performance design as separate skill sets. The faculty consists of international-level practicing filmmakers, scenographers, and practice-based researchers. DoF values its nearly 60-year-long tradition but is actively exploring future challenges and emerging technologies with new workflows. It works closely with the audio-visual industry, theatre, and emerging contemporary post-dramatic performing arts. The primary focus area of DoF is audiovisual storytelling. We are educating future experts and artists in the field of film, television, and performing arts, and we are expanding to new formats, such as virtual and augmented reality. DoF fosters a critical approach to storytelling and cinema.

Highlights of the panel assessment of the unit

The unit's artistic work is of excellent significance and rigour, and apt to generate significant interest within the international community of film schools and beyond. The department has the distinction of being the only university-level film school in Finland; it is also the only institution educating costume designers and scenographers. This places it in a unique position to showcase, at top international level, the outcomes of the educational, research, and artistic work being conducted by the department. The department's research is predicated on film, theatre performance, and production, and it takes various methodological and conceptual approaches, either as artistic-based research, practice-based research, or critically driven research, a rhizomatic stance that makes it suitable for dissemination amongst leading international players in the field.

There is evidence in collaborative work with reach beyond the university that also builds on the fundamentally multidisciplinary nature of the education provided by the department. It is clear that the Department of Film contributes well to the university's ethos of art and design knowledge building and artistic research practice, but there is less evidence of research-led practices that cross with other schools within the university and even with some of the other departments in the school, something that should be reinforced in the future.

A reinforcement in the level of international collaboration and related funding acquisition could further reinforce the department's quality and its degree of innovation.

Department of Media

Description of the unit

The Department of Media is an academic community of approximately 330 students and 40 faculty members, established in 2010. Our education and research occurs within three field-specific units: the Media Lab (new media, game design, and sound in new media); photography; and visual communication design (information design and visual narrative). Research within the department is organized as personal studies (at the master and doctoral levels), via thematic research groups, and with external partners. Media is approached from various starting points, including audio-visual communication, art, media design, expression and storytelling, interaction, production, and new and experimental forms of media, as well as the development of tools, instruments, and procedures for creative media design and production, and their application in various multidisciplinary fields.

Highlights of the panel assessment of the unit

The Department of Media is a hybrid unit integrating historical initiatives pre-dating the formation of Aalto University. The department is comparatively small and had been focusing on building collaborative research with, for example, the School of Science and the School of Electrical Engineering. Three credible areas of research and creativity are identified through the three case studies: The Helsinki School, Virtual Heritage, Sonic Interactions.

The Helsinki School of Photography is an important and internationally recognized initiative that demonstrates the legacy of the department dating back to the 1990s and evidences continued productivity. The list of ten significant achievements in the census period suggests that photography output and impact dominates the department in terms of its international excellence and recognition. Seven of the ten examples are photographic outputs. The department has been investing in research in the areas of virtual heritage and sound for new media. Both show strong potential for development.



Field: 2
Business and Economics

***Marno Verbeek, Chair;** Peter Norman Sorensen;
Salvador Carmona; Randi Lunnan; Thorsten Hennig-Thurau;
Steve Brown; Daniel Guide; Susan Marlow; Jonathan Wareham.*

Field Description

The Business and Economics (B&E) research field comprises seven departments at Aalto University: the six departments in the School of Business (BIZ) and the Department of Industrial Engineering and Management in the School of Science (SCI). The B&E field has developed into an outstanding research community, both in terms of quality of research and impact.

Aalto's BIZ is a comprehensive business school that covers all core areas of business studies and economics. It was the first among Nordic countries to be triple accredited by AACSB, EQUIS, and AMBA (in 2007). During the last decade, the school has transformed itself to become internationally oriented and is one of the leading research institutions in Europe. The Department of Industrial Engineering and Management in SCI is today one of the leading research units in its field in Europe.

With approximately 120 full-time faculty members (professors and lecturers), the research area at Aalto University is considerably smaller than in most of its main competitors.³

BIZ advances the global body of knowledge in business studies and economics through excellence in research, contributing to the development of business and society. Important business and societal challenges serve as drivers of research efforts carried out in the school, addressing key questions related to the dynamics of business in the context of an increasingly globalized service economy. The research activities in the Department of Industrial Engineering and Management cover key areas at the intersection of engineering, management, and entrepreneurship, building on a thorough understanding of technology industries. It provides complementary strengths to the B&E field with a focus on technology-based business.

A particular strength of research carried out within Aalto is the oftentimes extremely close collaboration with industry as well as with the public sector and other societal actors that allows researchers to gain access to unique and highly valuable data for research and also helps to contribute to the development of the partner organizations. In this overview, we refrain from commenting on the specificities of the outstanding research and the profound impact of the work carried out in each of the seven departments; rather, we refer the reader to the reports in which the departments present their own research activities and outcomes.

³ European competitors in the B&E field in Nordic countries include: Stockholm School of Economics, Copenhagen Business School, the Norwegian School of Economics, and the Norwegian School of Management. Rotterdam School of Management and the University of St. Gallen are also seen as benchmarks. The B&E field is comparable in size with Stockholm School of Economics, but is smaller than its other benchmark Nordic and European competitors.

Excellence, Quality and Multidisciplinary Collaboration in Research

Key indicators of excellence of research within the B&E field include the number of articles published in top journals (FT50/ABS4) and the academic impact of the articles. The percentage of Top 10% publications⁴ is used as a key performance indicator.

During 2013-2017, B&E scholars published 113 articles in journals included in the FT list and 107 ABS4 articles (excluding FT-listed articles). Moreover, the trend in the number of top publications per year is positive⁵. In terms of the output per faculty member, Aalto University is ahead of its Nordic competitors in the areas of business and economics, and it performs well in relation to the very best European universities and business schools.

The outstanding quality of research in B&E is evident in the excellent publication citation impact scores that compare well with those of Nordic and other European benchmark institutions. Aalto University also does well in international rankings in B&E.⁶

Addressing the critical societal challenges of today and tomorrow often requires multidisciplinary approaches. While there has already been an increase in multidisciplinary research (see individual reports), the aim is to further increase the number and the impact of highly ambitious multidisciplinary research projects in the years ahead. Within Aalto University, scholars are encouraged to participate in university-level research Platforms. For example, the Entrepreneurship Platform⁷ connects scholars in the area of entrepreneurship research and education.

Impact on the Research Community

The very significant impact of Aalto B&E scholars on the global research community is evident in the citation scores of our researchers (for the Top 10% scores, see the individual reports) and in the research-based rankings of Aalto University. In addition, as described in each of the departmental reports, a number of professors contribute to the international scholarly community by serving as journal editors, special issue editors, members of editorial boards, conference chairs, and organizers of academic workshops.

⁴ Top 10% publications include those that belong to the top 10% most cited publications in the same subject area, document type, and time period in the world. This indicator is used by Aalto University to evaluate all research fields within the university. It is also a key measure used by the Academy of Finland in its assessments of the national research quality.

⁵ There was a drop in the number of articles published in top journals in 2017, but the year was still the second best ever for B&E. The situation at the time of writing indicates that the numbers will increase again in 2018.

⁶ For an overview of the international rankings of Aalto University in the area of B&A, please see <http://www.aalto.fi/en/about/ranking/>.

⁷ The Entrepreneurship Platform was established in 2018 and is still in a ramp-up phase.

Societal Impact, Entrepreneurial and Innovation Capacity

There is today much focus on the societal impact of the activities carried out within B&E. Our researchers tackle a wide range of important societal challenges related to business studies and economics. As outlined in the department reports and described in more detail in case studies, B&E's research-based contribution to society covers numerous areas and takes many different forms and shapes:

- *Collaborative research with corporations and other societal actors*; not only are new insights co-created in such research, but key organization decision makers are also directly influenced by the value of joint research processes.
- *Sharing insights from research through active participation in media, including TV and the press*; B&E professors are today among the most sought-after and influential commentators in the university sector in Finland.
- *Executive education*; most of the faculty members teaching Aalto University Executive Education programmes (with a turnover of more than 20 million euros per year) come from the seven B&E departments.
- *Policy making*; experts from B&E are extremely actively involved in shaping national policy making, being often asked to serve as members of committees charged with formulating new national laws and regulations. They are often asked to comment on key national issues in Parliament and directly to Ministries, and there are many examples of national policies having been significantly influenced by our scholars.
- *Knowledge-sharing events*; some events are targeted to the general public, some to experts in a certain field, and some to alumni.

The vibrant startup ecosystem that has emerged in and around Aalto University is constantly referred to as a key achievement and has played a transformative role in changing the attitudes toward entrepreneurship in the whole country. Our scholars are at the international forefront in entrepreneurship research, and this work forms the intellectual basis for the educational programs in entrepreneurship offered within the university. However, B&E's influence on entrepreneurship goes well beyond the boundaries of the university and involves a range of actors, including the students' Aalto Entrepreneurship Society (AaltoES), the largely Aalto student-driven Slush (organizing a yearly start-up event in Helsinki with some 20,000 participants, an event exported to Shanghai, Tokyo, and Singapore) and the Kiuas accelerator programme.

Research Environment

Much focus is placed on creating conducive research environments for early-career and senior scholars alike. In general, there is a culture of faculty members coming into the office rather than working from home. The relatively

large number of PhD students also contributes to producing a dynamic and lively research environment.

Many departments organize research seminar series where leading international researchers and own faculty members present their work. Some series are department-internal, and some organized across departments and/or universities. For instance, Helsinki Research Seminars are organized by the departments of Management Studies and Industrial Engineering and Management with Hanken School of Economics, bringing together researchers from the Helsinki region as well as international visitors to discuss papers that have received 'revise and resubmit' decisions from top journals. The Department of Economics co-organizes a research series with colleagues from the University of Helsinki and Hanken, and in finance, there is a joint research series with Hanken.

The research environment of all departments benefits from the presence of international top scholars as visiting professors. BIZ provides funding for visiting professors within its Distinguished Visiting Professor initiative, and the school offers generous funding to departments to invite foreign scholars to visit the school to give research talks. Similarly, the Aalto Science Institute, hosted by SCI, provides funding for both inbound and outbound professor mobility. Since Finnish society is exceptionally open to sharing information, we are in an excellent position to attract visiting scholars and new faculty members who are interested in working with unique Finnish data, often in close collaboration with local enterprises or the public sector. Both faculty members and doctoral students are encouraged to spend time at leading international universities.

Future potential

Aalto University is already among the best research units in B&E in Europe, especially given its relatively modest size and resources. Our faculty members address important societal issues and make significant contributions within academia and society at large. The faculty tenure structure is young, with roughly half of professors are assistant professors. We are convinced that there is good potential to further develop the quality and impact of our research related to business and economics carried out within the university.

Going forward, it is important to be able to continue to recruit, inspire, and retain excellent faculty members in tough competition with business schools and universities with more resources. Continuing to offer scholars an inspiring, ambitious, and conducive research environment is important as is making sure that there will be sufficient resources for researchers to pursue scholarly excellence and make tangible contributions towards better business and a better society.

Bibliometric analysis

The research output of B&E has been reasonably well covered by WoS over the years. The fact that our citation impact is 20-30% above world average (MNCS) and even between 0.14 and 0.16 for PP(top10%) is therefore representative for this field. Around 75% were completed in collaboration with other organizations, and around 50% involves international partnerships. Aalto researchers in Field 2 manage to publish in high-impact journals. Collaboration with industry is relatively low, which is common in these research areas.

Table 4: Overview performance (output and impact)
Field 2 – Business & economics, 2012-2016

	Publication number	Journal score (MNJS)	Internal coverage (IC)	Citation score (MNCS)	Proportion of Highly cited Publications PP (top10%)	Proportion of Publications PP (collab)	Portion of Publications PP (intl collab)	Portion of Publications PP(industry)
2012-2013	292	1.22	0.61	1.21	0.15	0.74	0.44	0.05
2013-2014	324	1.43	0.61	1.32	0.16	0.75	0.49	0.02
2014-2015	300	1.39	0.63	1.25	0.15	0.75	0.51	0.00
2015-2016	328	1.35	0.64	1.32	0.14	0.77	0.57	0.02

Looking at the top most frequently published journal categories (Management, Business), we measure high scores of MNCS and MNJS. In WoS journal categories in which these researchers publish less frequently, the impact is sometimes low. In these categories, however, the volume of output is very low.

The collaboration profile shows that the highest impact is achieved where international collaboration is involved. This type of collaborative work is also published in the higher impact journals (MNJS).

Panel's Field Assessment

The field of business and economics is important to the development of Aalto University, building upon a long history of research and teaching in these disciplines. The field comprises seven departments: six in the School of Business and one, the Department of Industrial Engineering and Management, in the School of Science. After studying all written and presented material, and speaking to many stakeholders at Aalto University, the *panel was unanimously impressed by the overall quality of the research and developments* over the past years. Without a doubt, the tenure-track system, in combination with an increased focus on internationalization, quality, innovation, and impact, has played an instrumental role in bringing this field, and all departments in this field, to their current high level. The Aalto brand has become strong in business, management, and economics, and we feel it has the potential to strengthen even further in the years to come.

In addition to the scientific quality, the panel was also impressed by the *collegial atmosphere and the open, non-hierarchical culture* of Aalto. Across all ranks, academic staff appeared to be proud of being part of the Aalto community. Critical remarks appear to be very constructive. Several staff members spoke very positively about Aalto and its low level of bureaucracy relative to their previous organizations. All in all, this indicates that Aalto University has been doing very well in recent years.

In the field of business and economics, the overall focus is on publications in top international outlets, particularly in journals from the lists used in the Financial Times rankings (FT45, now FT50), and those in categories 4 and 4* of the Academic Journal Guide of the Chartered Academy of Business Schools (ABS). (There is a high degree of overlap between these sets of journals.) This selection of journals is not only based on citation metrics, but it also considers their standing and reputation in the field among experts and scholarly associations. Publication space in these journals is highly competitive, and rejection rates are very high (typically well above 90%). In addition, publications in these journals play a crucial role in tenure and promotion decisions, with less weight being given to publications in ABS3 journals or below (depending upon the particular sub-discipline).

Given the relatively small size of this field (compared to its international benchmarks), the number of publications in the FT list and ABS4/4* list (excluding FT-listed articles) over the past five years is impressive (113 and 107, respectively), such that Aalto is comparable to other reputable European universities and business schools. There is also a clear upward trend, albeit with a small dip in 2017. From the CWTS bibliometric analysis, we note that the citation impact of the field as a whole (averaged across all publications during 2012-2016) is 20-30% above

Research profile

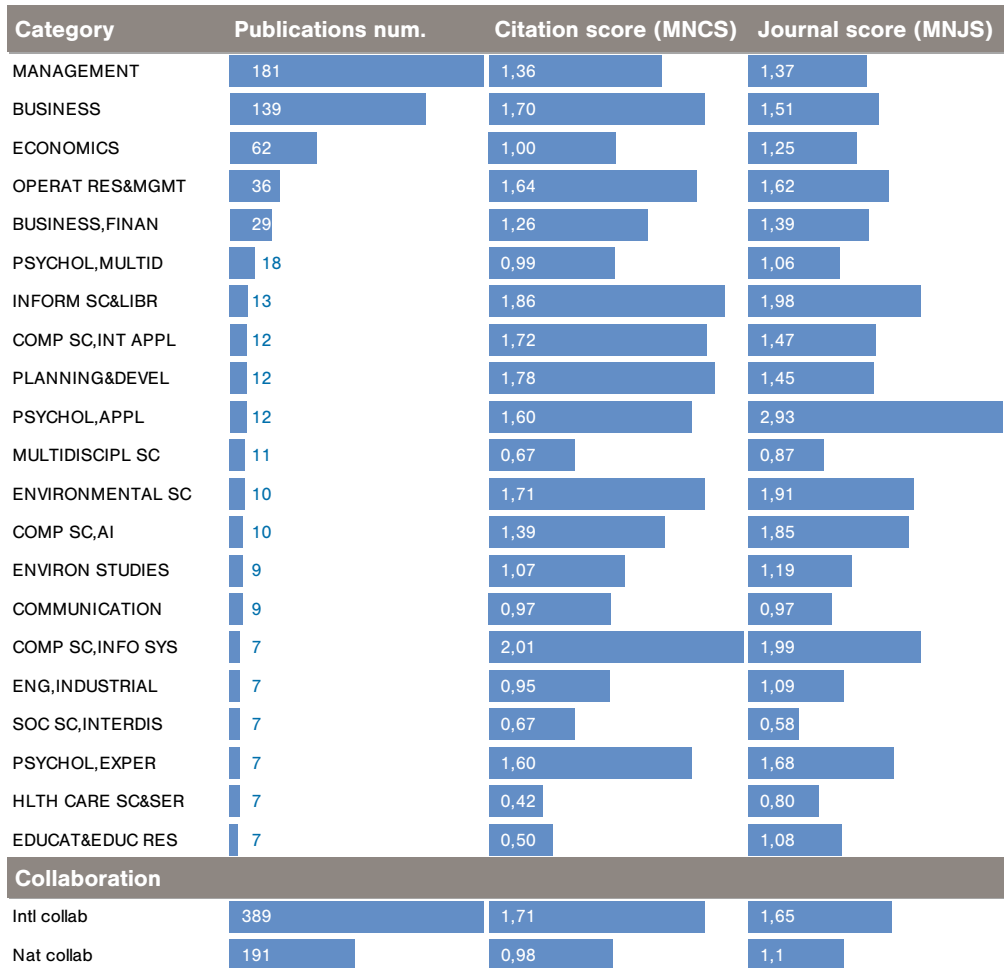


Figure 10: Research and Collaboration profile (output and impact)

Field 2 – Business & economics, 2012-2016

As a whole, the field is quite excellent. The Aalto brand has strengthened and is strengthened by the business, economics, and management departments. It is an attractive environment for international scholars with a positive culture and is mostly well resourced. There is scope for further improvement, although attracting and retaining academic talent become more challenging with the field improving in terms of quality and internationalization of research staff. Further improvements can be found in further optimization of the organization of the three departments covering overlapping parts of the management discipline.

world average (MNCS), while approximately 15% of the field's publications are among the 10% most cited papers in the field (PP top 10%.) There is some variation across departments, but overall these indicators are excellent. Focusing on newly recruited research staff, these metrics are even better also suggesting an upward trend in research impact.

As in many fields, international competition for top academic talent in business and economics is extremely high. Therefore, providing an attractive and well-resourced research environment, in combination with a competitive compensation package, is important to attract and retain research staff. As mentioned above, Aalto provides an appealing working environment with a healthy work-life balance, a good internal culture, high-profile visiting scholars, and a low degree of hierarchy. The resources for scholars are good. An important asset is access to high-profile empirical data, and the facilities and support to handle them. More broadly, the *research environment is well-resourced* and includes an attractive personal research budget for many (junior) hires. Teaching loads are moderate across all ranks, and students are motivated, which makes teaching particularly rewarding. Salaries for junior research staff are reasonably competitive within Europe (excluding the very top schools, e.g., London Business School and INSEAD), making Aalto an attractive option for junior scholars. For senior research staff, compensation packages appear less competitive, even relative to schools that are geographically very close. Moving forward, this may be a point of concern, particularly given the increased focus on quality and internationalization.

The future of the field of business and economics includes many important challenges and opportunities, for example, related to digitalization, globalization, social inclusion, big data analytics, the impact of disruptive technologies, (social) innovation, entrepreneurship, and smart solutions. In general, all departments in this field at Aalto University are in very good shape to address these future challenges. However, we also note that competition in this area is tough, with many schools across the globe striving to climb on the ladder of excellence. This leads to an increasingly intense competition for academic talent at all career levels, for grants and projects, and for space in the top academic outlets. It also drives up international salary levels, while it increases mobility of good scholars. Given the constraints at Aalto University regarding remuneration, and given the limited potential for overall growth, we have rated the future potential of each department with the above observations in mind.

Department of Accounting

Description of the Unit

The Department of Accounting is one of the leading research faculties in Europe comprising the domains of accounting and business law. Its excellent research builds on interdisciplinary theoretical perspectives, the availability of unique data sets in Finland, easy organizational access, and cooperation with top researchers from other universities. We target excellence in a number of key areas: In financial accounting, the emphasis is on the interplay between the regulation of financial reporting and the users of financial information – including corporate governance and auditing. In management accounting, we focus mainly on performance measurement and management control. In business law, the objective is to apply methods of both legal science and business economics, developing a methodological toolbox based on a combination of these. This adds value through innovative applications of legal tools in business strategy and planning. The societal impact of our research remains at an excellent level. Our professors have a major role in developing accounting and business legislation, as well as in the ongoing reform of the Finnish health sector.

Highlights of the panel assessment of the unit

The Department of Accounting at Aalto University is performing very well and is on an improving path. Accounting research is especially significant in three areas: management accounting and control; auditing; and corporate governance. Publications in these areas have targeted well-regarded, generalist and specialist journals. Benchmarking the department with comparable Nordic departments shows a very good record. This overall assessment of the Department of Accounting should take into consideration that its student/research staff ratio is high. The department leads Aalto University in its participation in Aalto's Executive Education programmes.

The panel notes a very good, improving publication record, international standing via citations, editorial positions, reviewer activities, and hosting an upcoming EAA conference.

There is an attractive working environment with good seminars. It would be desirable to build on the upward publication trend of the department, and on its relatively strong Nordic position, to further develop its international atmosphere. Some areas of improvement include: a) hiring international scholars, as it is becoming usual at Aalto University, and b) providing support to the department's PhD students in getting international placement after completing their theses.

Department of Economics

Description of the Unit

The Department of Economics at Aalto University BIZ is the leading economics department in Finland, both in terms of research and societal impact. The department is committed to outstanding research and research-based education at all levels. In the field of applied microeconomics, the departmental research quality is globally competitive and, in core focus areas, comparable to the best European business school departments. The department shares its physical location with the economics departments of Hanken School of Economics and the University of Helsinki. These three departments bear the responsibility for doctoral-level education in economics for the entire country. The Aalto Economic Institute (AEI) is a departmental excellence project that coordinates the societal impact of the department. External partners collaborate with the department on significant economic problems with potential for future research output through projects facilitated by AEI.

Highlights of the panel assessment of the unit

The Department of Economics' research is excellent. The department is comparatively small but consists of some excellent individuals who function well as a focused group. Members of the department have published an impressive number of articles in the internationally leading economics journals with rigorous editorial standards. It is on an upward trajectory of top publications with citations, attributed to its increasing share of research staff in the more productive stages of their careers. Some of their work is internationally excellent in terms of originality, significance, and rigour, generating considerable interest within the international research community. The department is active in multidisciplinary research, as exemplified by top publications that resulted from joint work with psychologists and demographers. The department is also on an upward trajectory in hiring and placing its PhDs on the international market.

The panel recommends the department continue cooperation within the newly established Helsinki Graduate School of Economics, which is an excellent means to offer high quality doctoral education in economics in Helsinki and to further improve international placement of PhD graduates. To further support future excellence, the department should concentrate its efforts on securing ERC grants. The department should take some effort to ensure that its past success with impact on the Finnish society continues.

Department of Finance

Description of the Unit

The Department of Finance is an outstanding international research unit, with focus in behavioural finance, corporate finance, and asset pricing. In recent years, we have consistently been around the top 10 in Europe based on high-quality research impact. In behavioural finance, the unit is a forerunner in Europe, with notable impact on the development of the field, with key studies having thousands of citations. Our professors hold prestigious personal grants (e.g., Academy Professorship), important positions in influential academic associations (e.g., Director at European Finance Association), are sought-after experts in tenure committees and other professional tasks (e.g., National Science Foundation reviewers), and are regularly invited to speak at the most significant conferences (e.g., American Finance Association). Doctoral alumni are employed at globally leading universities like the University of Chicago, London Business School, Imperial College, the University of Miami, Hong Kong University of Science and Technology, et cetera.

Highlights of the panel assessment of the unit

The department's research is quite focused with a strong emphasis on investor behaviour and behavioural finance. An important asset is our access to very large databases and the ability to deal with such data. Because the department is quite small compared to most of its competitors and benchmarks, quality, as measured by the absolute number of top publications, is very good. Taking into account the composition of the department (with a relatively high number of junior research staff), it is excellent. The societal impact of the department is good and comparable to the many international departments in this field. Much of the impact concentrates on impacting policy formulation or the financial industry. Some department members are very popular in the Finnish news media, contributing to the broader understanding of investing, business, economics, and policies on these issues.

The potential of the department is very good. However, its small size makes it vulnerable. Ideally, for a business school, this department should be expanding in the years to come, also in relation to the high demand for financial training and education internationally. To increase its international standing and reputation, more international top publications should be emphasized to create a frequent and regular presence of Aalto scholars in top finance outlets. The department could explore further opportunities for interdisciplinary cooperation within the larger Aalto community, for example related to entrepreneurial finance (venture capital, crowdfunding). At this stage of development, we do not encourage the department to engage in large and demanding interdisciplinary projects.

Department of Management Studies

Description of the Unit

The unit of assessment comprises the Department of Management Studies (DMS) and the multidisciplinary research centre, the Centre for Markets in Transition (CEMAT). DMS is one of the very best units in its field in Europe. During 2013-2017, the department produced 71 FT50/ABS4 level publications, obtained external research funding amounting to €15.5 million, and 27.74% of its publications were in the top 10% most cited documents in the subject category with a category-normalized citation impact of 1.94 (InCites). DMS has been at the forefront of establishing and implementing multidisciplinary research projects at Aalto University including the university-wide initiatives, the Entrepreneurship Platform and the Sustainability Hub. The combination of high-quality research and multidisciplinary orientation allows DMS to effectively engage with some of today's societal challenges to contribute to a better society. DMS has pioneered several such research areas and developed a leadership position within these areas. Examples include sustainability in business, economic and societal inclusion, population ageing, digitalisation, transition to clean energy solutions, and the changing nature of work.

Highlights of the panel assessment of the unit

The panel was very impressed by the quality of output of the department in terms of publications and funding. The panel was particularly impressed with the profile of staff in terms of their engagement as editors, reviewers, and editors of special issues in top-rated journals, indicating high levels of esteem. There is clear evidence for academic involvement and research dissemination through diverse avenues, and strong company collaboration with high potential for further impact. The panel applauded the impressive research efforts and output.

The Department of Management Studies rightly recognises that the retention of key researchers and steady growth with new tenure-track positions are essential for achieving the goal of being a leading management research hub in Europe. The panel also recognize that the diversity of focus areas within the department could be problematic in the future as resources could be spread too thin without obtaining the necessary focus. Consider a stronger involvement in Aalto Executive Education programs, as this will certainly enhance the societal impact of the department and provide further research opportunities.

Department of Marketing

Description of the Unit

The Department of Marketing is highly research-oriented and has achieved significant international visibility and impact in such fields as consumer culture theory (CCT) and strategic marketing. More specifically, the department has been acknowledged as the leading institution in the Nordic region along with BI Norwegian Business School regarding its research output in the top three ABS-categories. The group is strongly committed to safeguard its pole position in the Nordic region by continuing to produce publications of the highest international standards. The Department of Marketing offers an intellectually stimulating range of courses and covers the foundations of marketing at every level of higher education.

Highlights of the panel assessment of the unit

The Department of Marketing has an impressive publication record; its members have published several articles in the world's leading marketing journals and in other fields, such as strategy and organization. Given the relatively small size of the department, we find the research output impressive. The department's scholarly performance was also not dominated by a single scholar; instead, various department members have contributed to these successes. With a good number of publications and citations for the field, the bibliometric analysis shows a high mean normalized journal score of 1.66 and a very high mean field normalized citation score of 1.93. The benchmarking exercise places it above its Nordic competitors. The department places its PhD graduates well in the international market.

The panel found that the department collaborates well internationally and that its works have received a solid amount of attention. Members of the Department of Marketing are present in several boards and actively review for various journals; at the same time, we believe there is still potential for a higher visibility in the leading outlets in the marketing field. The Department of Marketing appears well connected to relevant Finnish decision makers. Through executive education and seminars, it appears that research knowledge is broadly shared. The panel recommends to the department to develop a worthwhile follow-up project to StratMark, extending and fleshing out the annual survey. This should be a high priority issue.

The department's resources are too limited, especially senior resources, and further expansion hinges on successful acquisition of good talent.

Department of Industrial Engineering and Management

Description of the Unit

The Department of Industrial Engineering and Management (DIEM) conducts world-class research and provides impactful education focusing on the creation and transformation of technology-based business. The department is one of Europe's leading university departments in technology entrepreneurship in the fields of strategic management, operations management, and entrepreneurial leadership. In total, there are more than 120 persons working in the department, including 20 professors, over 30 senior and postdoctoral researchers, and more than 100 doctoral students. The department conducts empirical research in close collaboration with leading technology firms in Finland and Europe. DIEM provides doctoral education for students employed full-time at the department and students working part-time in industrial firms. Moreover, the department provides entrepreneurship education for students of other departments at Aalto University in collaboration with many entrepreneurs through the Aalto Ventures Program.

Highlights of the panel assessment of the unit

There is evidence for a strong interdisciplinary collaborative profile within the department, which reflects key strategic aims and objectives of the university in terms of innovation and entrepreneurship such that the intersection of engineering, technology, and innovation generates a strong nexus for knowledge exchange and transfer. This is an impressive profile where the interdisciplinary profile of the department has reaped rewards through a strong publication record and an impressive reservoir of research funding. The collaboration between industry and academia is well-established whilst evidence has been provided regarding how research feeds into teaching. This is a strong department with good leadership, a very strong publication profile, and funding.

The work being undertaken in this department is of great relevance to many other departments at Aalto. At some level, it may be worth exploring a greater level of integration, or the creation of trans-disciplinary research units to facilitate collaboration across departments. Much of the emphasis in the documentation has been upon entrepreneurship - particularly encouraging technology, growth-oriented startups - gathering sound evidence for the efficacy of this strategy would be useful in terms of survival and scalability.

Department of Information and Service Management

Description of the Unit

Information and Service Management refers to the creative use of information and digital technology in business and the move from industrial- to service-dominant forms of production. The increased use of software and advanced analytics in all kinds of enterprises and public-sector organizations have created a need for PhD graduates who can work at the interface of business and technology. Researchers in the department study such topics as digital service development, digital business models, supply and service networks, sustainable supply chains, behavioural decision making, mathematical modelling of business problems, and data science. The research in the department is broadly divided into three disciplines: information systems science, logistics, and management science. These disciplines have excellent synergies, and they are at the core of modern digital society. Taking into consideration our resources, we are currently among the leading departments in our research areas in Nordic countries, as well as at an excellent level among European business schools.

Highlights of the panel assessment of the unit

The department facilitates very good connections to industry and government. The Department of Information and Service Management supports a number of Professors of Practice. A number of impressive impact cases were presented that demonstrated direct adoption/implementation by public authorities. The unit's work is internationally recognized. The department has a number of senior scholars that are well-recognized. It has strong academic leadership in associations and editorial boards. The department is currently performing very well at a European level. Increased focus and investment in younger and mid-career research staff would help it obtain greater scale and impact defined areas. The future of the department is potentially bright.

There is much scope for the field of business and economics to further explore cooperation with other fields and disciplines. With this, it should be kept in mind that the number of senior research staff members in business and economics is relatively limited. Moreover, it makes sense for the field to seek collaboration with fields and institutes that are not part of Aalto, for example, in sociology, psychology, or health economics. Senior researchers in the meetings mentioned a lack of real infrastructure to support interdisciplinary cooperation across different schools. We recommend giving appropriate attention to this issue with the School of Business moving to the Otaniemi campus.

3a

Field: 3a

Chemical engineering and physics

***Heiner Linke, Chair;** Emiel Hensen; Arno Villringer;
Pär Jönsson; Erling Halfdan Stenby; Jan Lagerwall;
Robert Pelton; Lisbeth Olsson.*

Field Description

The field Chemical Engineering and Physics combines research and innovation activities of five departments from two different schools, the School of Chemical Technology (CHEM) and the School of Science (SCI) at Aalto University: the Department of Bioproducts and Biosystems (CHEM), the Department of Chemistry and Materials Science (CHEM), the Department of Metallurgical and Chemical Engineering (CHEM), the Department of Applied Physics (SCI), and the Department of Neuroscience and Biomedical Engineering (SCI).

The research conducted in chemical engineering and physics mainly relates to Aalto University's key research area, *materials and sustainable use of natural resources*. From a multidisciplinary perspective, it has strong connections to the Materials Platform, Energy Platform, as well as Health and Wellbeing Platform, which all contribute to Aalto's grand challenge areas.

The field builds on the considerable strengths of Aalto University in bioeconomy, circular economy, materials science, and quantum technology, as well as in health technologies. More specifically, the field covers 10 focus areas: 1) materials for energy science, 2) nanostructured hard materials, including modelling and devices, 3) quantum technology, 4) metals processing, 5) chemical engineering, 6) biomaterials and soft materials, 7) fiber and polymer engineering, 8) industrial biotechnology, 9) neuroscience and -technology, 10) biomedical engineering and

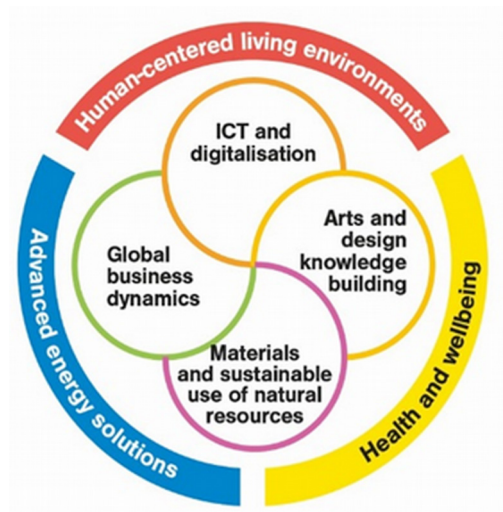


Figure 11: Aalto University's four core competence areas and three multidisciplinary themes.

biophysics. The focus areas are also reflected in forums in which the units publish scientific articles (*Figure 12*).

Outstanding research quality

With over 4 000 peer-reviewed journal articles in 5 years, Field 3a Chemical Engineering and Physics is the most productive. At the same time, the quality and impact of the output has increased throughout the assessment period. For instance, we published 60 articles in *Nature* series and 3 articles in *Science* during 2013-2017. The high number of citations in very competitive field of multidisciplinary material sciences reflects the significance and impact of our research. Furthermore, we have demonstrated a strong international networking capability, as 63% of peer-reviewed journal articles written in collaboration with international partners.

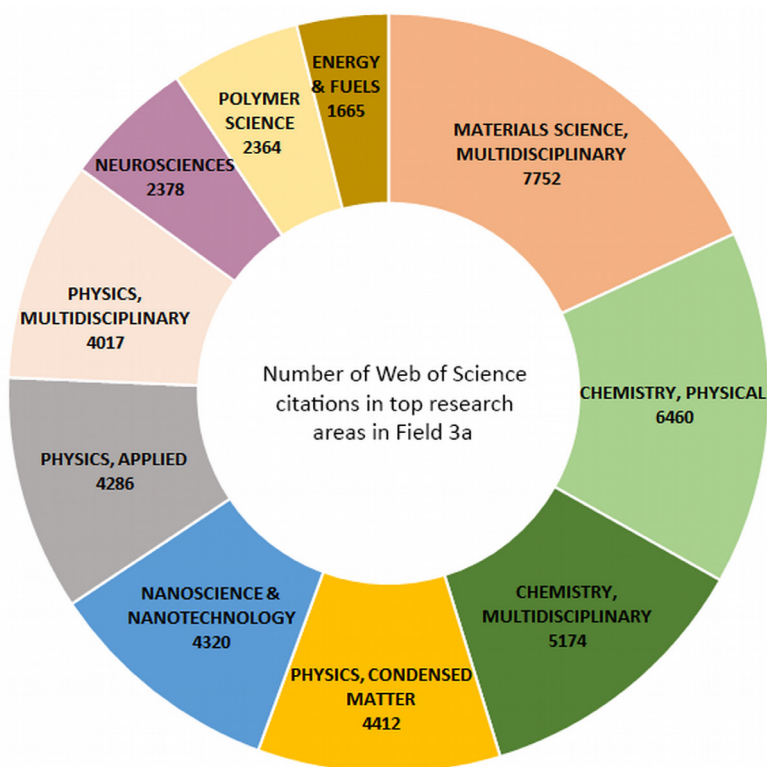


Figure. 12: Publications forums in Field Chemical Engineering and Physics.

This field has 74 tenure-track professors, which covers about 20% of all such professors at Aalto University. The high quality of professors is recognized nationally and internationally, and our professors are recipients of international recognitions and hold prestigious personal grants. We have two Academy of Finland Academicians, eight Academy of Finland Professors (73% of all at Aalto), and one double ERC Advanced Grant holder. Together, we have received 22 *ERC grants* (76% of all at Aalto) during the assessment period. The professors in the field are also sought-after experts in international committees and chair appointments, and they are regularly invited to speak at the most significant conferences in the field. Field 3a is very international, which can be seen in the share of newly recruited professors (more than 30% come from outside Finland), and in the share of international academic personnel, which is the highest at Aalto: 47%. The faculty in this field play important role in Aalto's multidisciplinary platforms, which is realized in the substantial number of co-authored publications and double-affiliated professors with other schools. This field educates the largest number of doctoral candidates at Aalto. We are ambitiously developing our doctoral programme, and produce around 70 doctoral degrees per year. The alumni of the field are employed by globally leading universities.

Exceptional research environment

The field Chemical Engineering and Physics has hosted no less than three national Centres of Excellence (CoEs): (i) Centre of Excellence in Computational Nanoscience, COMP (2012-2017), (ii) Centre of Excellence in Low Temperature Quantum Phenomena and Devices, LTQ (2012-2017), and (iii) Centre of Excellence in Molecular Engineering of Biosynthetic Hybrid Materials, HYBER (2014-2019). In addition, we are partners in several leading European collaborations: (i) EU Centre of Excellence for Novel Materials Discovery (NoMaD Laboratory), (ii) Graphene FET Flagship, (iii) FET proactive in Hybrid Optomechanical Technologies (HOT), (iv) EIT RawMaterials and (v) EIT Climate-KIC.

The field covers four crucial infrastructures that are in the Academy of Finland's national research infrastructure roadmap 2014-2020. First, OtaNano infrastructure offers nationally unique and internationally competitive micro- and nanotechnology capabilities in materials growth, processing, characterization, and nanofabrication. Second, Bioeconomy contains selected research infrastructures for development of chemicals, fuels, fibre products, and materials from renewable biomass utilizing biotechnical, chemical, and thermal processing technologies. Third, RawMatTERS infrastructure concentrates on advantageous metallurgical processes for primary and secondary raw materials (circular economy) and has a large range of sophisticated methods for functional materials and their characterization. The infrastructure also strengthens EIT RawMaterials

and the Baltic Sea Co-location Center that is located in Otaniemi. Fourth, Aalto NeuroImaging research infrastructure (ANI), which actively collaborates with the Helsinki University Hospital and the Faculty of Medicine at the University of Helsinki. With its cutting-edge MEG and TMS technologies and modern MRI, EEG, and NIRS, ANI is unique in its technical and neuroscientific expertise in electromagnetic brain imaging and stimulation. The departments in the field have been very active in building several recent spearhead centres at Aalto, such as the Centre for Quantum Engineering (CQE), Aalto Bioproduct Centre (A-BIO), and Health Technology House that host Aalto Brain Centre (ABC), Biodesign Finland, and the Institute of Healthcare Engineering and Management (HEMA). These centres further strengthen the four national research infrastructures.

Where science meets societal needs

The societal impact of the field is very large, ranging from economic and public policy to environmental and sustainability impacts as well as health and wellbeing. We have had a long-term collaboration with ICT, forest products, and metallurgical and chemical industry companies that cover major Finnish export areas, contributing significantly to the economy of Finland. Our master and doctoral graduates have a high employment rate in Finnish industry. Hence, our role to bring new knowledge to Finnish industry is crucial. The strong alumni network strengthens the impact and co-creation between the university and industry. As shown in our case studies, we have taken some of the innovations to the pre-commercialization phase with our stakeholders. We have also generated several spinoff and startup companies. During 2013-2017, the total number of invention disclosures in the field is 262.

Considering the profile of the field, environmental and sustainability aspects are obvious; we are looking for solutions through energy storage technologies, battery materials, solar cells, quantum technologies, and different circular economy aspects that are elucidated by the research of sustainable processes and their life cycle assessments for forest, chemical, and metallurgical industries. We are the national educator of nuclear technology and safety experts, and we are active participants in the European fusion programme. Our expertise is reflected in our work for national and EU energy and circular economy policies and directives. In addition, we serve our society in the health sector. Being a world leader in several ways in electromagnetic brain imaging and stimulation, we work closely with national and international hospitals.

Future potential

Around 50% of the professors in the field have been recruited between 2013 and 2017, meaning that faculty tenure structure is young. We are convinced that there is good potential to further develop the quality and impact of our research related to different focus areas in the field. To keep recruiting talented researchers and realize our potential, it is important to inspire our faculty in tough competition. Continuing to offer faculty an inspiring, ambitious, and conducive research environment, it is important to make sure there will be sufficient resources for researchers to pursue excellence and make tangible contributions toward better science and a better society. Indeed, we continuously develop our infrastructures and spearhead areas. By strengthening our focus areas (bioeconomy, circular economy, materials science and technologies, as well as in health and wellbeing), we are able to answer societal challenges and bring our novel scientific openings closer to stakeholders. This spring, the Academy of Finland awarded SCI several million euros in long-term competence cluster funding for Materials Bioeconomy under its new Flagship programme. A flagship is an effective mix of cutting-edge research, impact in support of economic growth and/or society, close connections to the business sector and society at large, adaptability, and a strong commitment from host organizations to meet set targets. Another rising area of expertise is quantum technology. The new Center for Quantum Engineering is an Aalto initiative to facilitate knowledge transfer especially to the technology industry. As a proof of excellence, success and new efforts in the area of quantum research, we received funding for the fourth Centre of Excellence, Quantum Technology Finland, QTF (2018-2025) from the Academy of Finland.

When looking at the renewal of Finnish major export companies today, it is obvious that the importance of ICT, forest products, and chemical and metallurgical industries will be crucial for Finnish wellbeing in the future. Furthermore, the role of quantum, health, and wellbeing technologies is gradually increasing. The ecosystems in those areas cover large corporations and small- and medium-sized enterprises. This strongly supports the idea that our faculty members will make significant contributions within academia and society at large in the future.

Bibliometric analysis

With almost 4 000 publications in 5 years, Field 3a Chemical Engineering and Physics is the most productive. The high internal coverage (IC) indicates that the WoS covers this area very well. The output in this Aalto field is published in high-impact journals (MNJS is 20% above world average). The impact of the output is above world average and is clearly increasing throughout the period of analysis (both impact indicators).

Table 5: Overview performance (output and impact) Field 3a – Chemical Engineering and Physics, 2012-2016

	Publication number	Mean normalized journal score (MNJS)	Internal coverage (IC)	Mean field normalized citation score (MNCS)	Portion of Highly cited Publications PP (top 10%)	Portion of Publications PP (collab)	Portion of Publications PP (intl collab)	Portion of Publications PP(industry)
2012 - 2016	3774	1.21	0.88	1.14	0.11	0.79	0.62	0.08
2012 - 2013	1390	1.19	0.87	1.09	0.10	0.79	0.60	0.11
2013 - 2014	1498	1.22	0.88	1.13	0.11	0.78	0.61	0.08
2014 - 2015	1597	1.23	0.88	1.20	0.13	0.78	0.62	0.06
2015 - 2016	1637	1.23	0.88	1.19	0.12	0.81	0.64	0.06

The proportion of output in collaboration with other organizations is around 80% throughout, while approximately 3 out of 4 involve international partnerships, and collaboration has increased slightly over the years. The overall output is substantial, while WoS coverage is high (almost 90%).

The proportion of output involving industry is typical for similar faculties at other universities in Europe. There is one department, though, with a much higher proportion, which is the Department of Bioproducts and Biosystems (PP[industry]= 0.14).

The research profile of this Aalto field shows only a few journal categories with a substantial output but in which the impact is somewhat lower. Still, the impact in categories with many publications is at least around world average and sometimes well above (physics - multidisciplinary, neurosciences, fluids & plasma and nano s&t). The large output and high impact in *multidisciplinary* journals for the entire university is apparently from researchers in this Aalto field.

The collaboration profile indicates, as usual, that output involving international collaboration has the highest citation-based impact as well as the highest level impact of journals in which we have published.

At the level of departments, we see some variety with regard to impact. This correlates strongly with the variety of impact of the journals (MNJS) in which they succeeded to publish. The Department of Applied Physics is worth mentioning, with a contribution to many papers (over 1 700, i.e., almost half of the Aalto field) and a high impact (MNCS of 1.33, PP [top10%] of 0.15), while the impact of their journals (MNJS) is 31% above world average.

Research profile

Category	Publications num.	Citation score (MNCS)	Journal score (MNJS)
PHYSICS,COND MAT	307	1,08	1,05
CHEM,PHYSICAL	268	1,03	1,15
MATER SC,MULTID	261	1,23	1,32
PHYSICS,APPLIED	230	0,97	1,01
PHYSICS,MULTIDIS	204	2,23	2,16
MULTIDISCIPL SC	179	2,23	2,10
CHEM,MULTIDISC	166	1,13	1,48
ENG,CHEMICAL	138	0,70	1,00
MATER SC,PAPER&W	135	0,67	0,73
NEUROSCIENCES	132	1,26	1,27
POLYMER SCIENCE	131	1,13	1,14
PHYSICS,FLUID&PL	106	1,41	1,21
NANOSC&NANOTECHN	94	1,27	1,29
OPTICS	88	0,53	0,80
PHYSICS,AT,MO&CH	79	0,84	0,90
ENERGY&FUELS	64	1,11	1,21
METALLUR&MET ENG	59	0,69	0,98
ELECTROCHEMISTRY	50	0,57	0,69
RAD,NUCL MED IM	49	1,24	1,59
BIOTECH&APPL MIC	49	1,31	1,43
NUCL SC&TECHNOL	48	1,56	0,90
Collaboration			
Intl collab	2338	1,23	1,27
Nat collab	648	1	1,07

Figure 13: Research and Collaboration profile (output and impact) Field 3a – Chemical Engineering and Physics, 2012-2016

Panel's field assessment

Focus of the review. In the written and oral presentations provided to us, we would have appreciated a more strategic outlook, more focus on scientific achievements ('game changers'), and less focus on numbers, which can be summarized elsewhere. Visibility of new areas represented by young faculty is lacking. We would have liked to meet more professors from different departments.

Department-level strategy. The panel recommends to encourage departments to develop a longer-term strategic vision, to articulate it, and to develop an action plan that: identifies focus areas for growth and devises a strategy for how to build critical mass; uses different parameters for measuring performance relevant in different disciplines. We recommend the university ask departments to set their own specific targets, define international peer institutions, and evaluate against those institutions.

Formation of C-'MATE'. The CMET and CMAT departments are both fairly small departments compared to benchmark universities. Both contain a combination of areas with a sufficient critical mass combined with other areas that need more faculty to be competitive. It is suggested that a project is initiated to study the benefits of combining CMET and CMAT in to a new C-'MATE' department of a larger critical size that has the potential to develop higher excellence and impact to reach the highest international reputation compared to benchmark universities.

PhD students. The PhD students the panel met seemed quite happy, and we did not perceive any major issues. However, there does not appear to be a clear, neutral point of contact in case problems do occur. Consider introducing the role of a PhD student ombudsman. The students experience a lack of courses targeting PhD students, and a lack of access to pedagogical training (bottlenecks, waiting times).

Gender. The panel observed a lack of strategy to address gender imbalance. Departments clearly need help. Elements of such a strategy can include better career counselling at all levels (including PhD students and postdocs), more diversity in leading positions, higher visibility of role models, active recruiting to level out imbalances, advertising positions with a gender perspective, incentives, and agility with respect to dual-career situations.

Seed funding. Seed funding can be a way to achieve important results with a relatively limited investment. Seed funding is available in some instances (e.g., through Platforms for multidisciplinary projects), but it could be useful to make such funding available more broadly, in particular for young researchers (PhD students, postdocs, assistant professors).

Lecturers. Some departments in the field appear to have a large number of lecturers compared to what is common in the peer departments they compare themselves to. There may be room for optimization of how funds are used. It is important that the departments themselves can fine tune the balance between use of funds for tenure-track slots, startup packages, support functions, equipment, and lecturers.

Sharing of best practices. The panel recommends creating a platform for systematic sharing of best practices between departments. Each department has areas where they excel, whereas in other areas, they could benefit from adopting approaches or cultures from other departments. Examples of such areas are: mentoring of young faculty; culture of attracting ERC grants; strategy with respect to diversity and gender equality; career counselling; mentoring of young faculty; nurturing industry contacts; shared equipment.

Recognition and incentives. The university's ambition to 'recognize and reward excellence' (see Strategic Plan) does not appear to be fully implemented in this field. Simple tools may be the introduction of awards (e.g., for teaching, innovation, mentoring, etc.) or distinguished professorships, for example.



Department of Applied Physics

Short description of the unit of the assessment

The Department of Applied Physics pursues vigorous research activities in the field of physical sciences with important industrial applications and technological potential. Much of the research is focused on condensed matter and materials physics, quantum physics, and nano optics - with topics extending from fundamental research to important applications - and on advanced energy sciences, which have particular societal impacts. For the future, special emphasis is diverted to quantum technology and engineering, and database-driven machine learning in materials research. The department also plays a leading role in the Otaniemi research infrastructure for micro- and nanotechnologies, OtaNano, a national resource for students, scientists, and high-tech businesses. Most importantly, we educate future generations of research and development, and data specialists, technology experts, inventors, and scientists for Finnish industry and society.

Highlights of the panel assessment of the unit

An excellent department with some truly world leading activities. The department's strength is its research excellence.

The department has a clear and focused profile in the field of condensed matter and materials physics, quantum physics, and nano-optics. The excellence of this department is evident from the large number of ERC grants (22 since 2010) and a high number of publications with a significant fraction of high-impact papers. Notably, personal grants include ERC Advanced, Consolidated, and Starting grants as well as other national and international (excellence) grants. The spread of the ERC grants over the different categories shows that the staff consists of a good mix of excellent, established as well as promising upcoming, researchers. Several researchers have also obtained (inter)national awards of high prestige. The number of peer-reviewed publications (including articles in top journals like *Science* and *Nature*) is high, with respect to the Aalto average, but more importantly also with respect to the worldwide field average. The department is very successful in attracting external (national and international) research funding, it leads the Centre for Quantum Engineering, and almost all groups have participated in CoEs during recent years. The new CoE on Quantum Technology is very timely and important for the future. The department has a very good level of measurable societal impact, primarily through its large production of MSc and PhD degrees (many of whom move on to industry or VTT), as well as through a number of spinoff companies; Bluefors is an outstanding example of societal impact.

Department of Bioproducts and Biosystems

Short description of the unit of the assessment

Bio2 is a world leading research and higher education unit that aims to provide novel solutions to help society transform to a sustainable economy based on the utilization of renewable resources. Bio2 groups work collaboratively with strong partners from industry and academia on transdisciplinary research themes. In forest products technology, our core competencies encompass the upstream selection of feedstocks, the pretreatment of lignocellulose biomass, and downstream unit operations. Bio2 uses novel approaches to the deconstruction and assembly of lignocellulosics into fibers, micro- and nano-particles, composites, and advanced functional materials. As for biotechnology, Bio2 covers the whole development chain: from strain and catalyst design to the bioprocess. Bio2 use synthetic biology, high-throughput screening, and modelling to design and optimize the performance of enzymes and microbes. Finally, using bioprocess design and optimization, Bio2 generates viable pathways and processes to targeted end products.

Highlights of the panel assessment of the unit

The Bio2 Department is world leading in fiber and nanocellulose research. The department is very well recognised, but still needs to publish more frequently in the very best journals. There is an outstanding utilization of results and versatile dissemination. Several examples are given of large projects/project consortia that have been shaped by Bio2. The strong interest and/or involvement from industry confirms the high level of excellence in these initiatives from an applied point of view. The extent of integration with industry and with VTT is impressive. The department's research is visible on the international arena, and the impression is that the research topics, to a large extent, are focused and well-integrated in the department. Two excellent case studies are presented with strong collaboration with industry. It is clear that the Ioncell and AaltoCell projects have strong societal impact.

The research environment presented appears to be outstanding. The collaboration with industrial players is important here. There is quite a significant equipment park, which makes the unit attractive. We encourage the department to develop a strategic plan, where the focus areas for the coming years should be pinpointed. The plan should encompass how to develop and make the biotechnology area prosper.

Department of Chemical and Metallurgical Engineering

Short description of the unit of the assessment

The department is at the core of basic chemical engineering skills in Aalto University's School of Chemical Engineering. The unique competitive edge of the Department of Chemical and Metallurgical Engineering is based on sustainability in better utilization of raw materials, designing more efficient processes, and developing new products. The department's areas of expertise are in chemical engineering, the metals process industry, energy technologies, and new materials production. They cover the complete chain: from scientific research and theory to overall concepts and practice. Personnel consists of 14 professors, 9 lecturers, 3 (senior) staff scientists, 16 postdoctoral researchers, and 64 other personnel (doctoral candidates, research assistants, visiting positions).

Highlights of the panel assessment of the unit

With 13.2 professors, CMET is small compared to many international CE departments (20+). Five of the professors work within the areas of metallurgy and mineral processing. This is the largest research grouping in the department. The remaining research areas have 1-2 professors, spanning the chemical engineering discipline. Nine of the 13.2 are new hires since 2015. The departmental publication record is strong, 125 in 2017 (9.5/professor). The emphasis is on new technology development with very strong industrial collaboration resulting in good funding. The polymer and metallurgy groups are likely to have the strongest international reputation currently. In terms of research initiatives, the circular economy of metals and bio-based polymers are particularly impressive. These are also two areas that address the urgent need in society to move away from our fossil dependency and better use of resources. In summary, CMET is in early stages of evolution with many new hires and more to come. Polymers and metallurgy are exceptional, whereas the other research areas need focus. CMET's societal impact is very strong, based on the number of postgraduate theses, the emphasis on sustainability in the research projects, contributions of government policy development, and the support of industry. Finland is a world leader in the forest products and minerals sector. Aalto and CMET are strong contributors to this leadership position.

Department of Chemistry and Materials Science

Short description of the unit of the assessment

The Department of Chemistry and Materials Science in the Aalto University School of Chemical Engineering was established in 2017 by bringing together chemists and material scientists with shared common interests: micro-, nano-, and atomic-scale engineering and reaction design toward novel compounds and materials, based on the development of innovative experimental and computational techniques. The research in the department focuses on advanced and functional materials, sustainable energy technologies, numerical modelling, and chemical synthesis and analysis, which are related in the bigger picture to next-generation electronics, future energy solutions, and medical and pharmaceutical applications. With a broad scientific repertoire covering basic chemistry disciplines as well as materials- and life-science-oriented focus areas, CMAT is able to provide their students with a solid background and a multidisciplinary competence profile across the chemical sciences. The strengths of the department include solid understanding of fundamental chemistry, seamless combination of experimental and computational methods, agility to collaborate with other departments, and an excellent international collaboration network.

Highlights of the panel assessment of the unit

The Department of Chemistry and Materials Science, which was only recently established, is relatively small and brings together researchers in 'sustainable energy technologies', 'functional materials' and 'chemical synthesis and analytics'. Given the small size, there could be more focus. There is some spread in the degree of excellence in terms of publications and the impact of the publications. It seems very good all the way around with some truly excellent activities, especially in the area of electrochemical energy materials. The research is mainly experimental in nature and is carried out in well-equipped laboratories with state-of-the-art equipment. The number of publications per professor is below the field average, but the number of top-10 publications is on par with a benchmark department. There is one top researcher with an ERC grant and accompanying Proof of Concept grant. The department clearly addresses some very important challenges and by some very competent researchers. CMAT are also involved in more than a handful of innovation projects, mostly in Finland but including two in Europe. CMAT also had a reasonable number of invention disclosures whereof roughly a quarter has led to patents, of which most have been transferred to the spinoff company to commercialize the ideas.

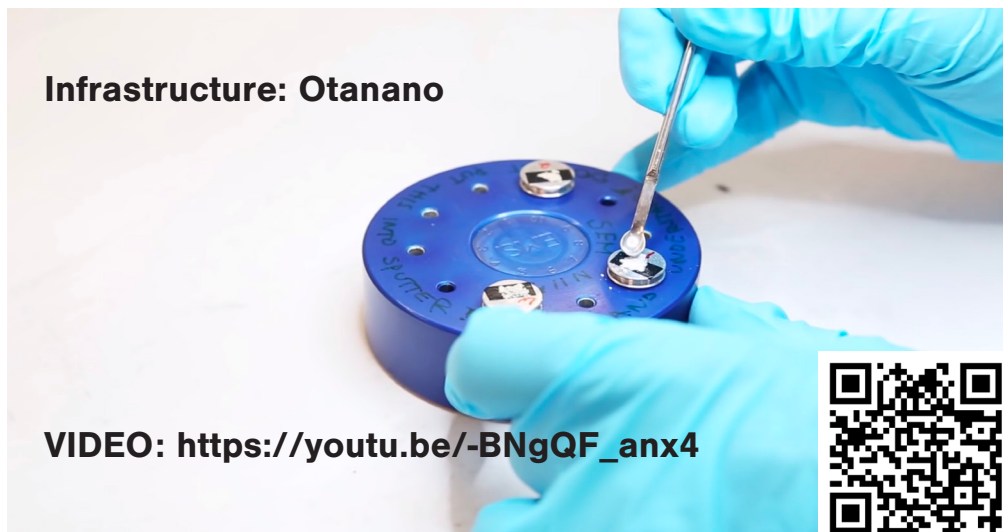
Department of Neuroscience and Biomedical Engineering

Short description of the unit of the assessment

Located in the Health Technology House on the Otaniemi campus, the Department of Neuroscience and Biomedical Engineering (NBE) focuses on systems and cognitive neuroscience, biophysics, and biomedical engineering. The levels of description range from molecular and cellular measures to noninvasive neuroimaging and behaviour. Based on the understanding of the physics and fundamental mechanisms in living tissue, we develop new technologies for neuroscience and diagnostic and therapeutic purposes, aiming at research- and teaching-driven discoveries and technological breakthroughs that contribute to health and wellbeing. NBE is responsible for the Biodesign Finland programme and two majors in the Life Science Technologies Master's programme. It hosts the Aalto NeuroImaging research infrastructure, several laboratories, and the Aalto Brain Centre. We actively collaborate with the Helsinki University Hospital and the Faculty of Medicine at the University of Helsinki.

Highlights of the panel assessment of the unit

NBE is among the world's best regarding the development of electromagnetic approaches for the assessment of brain function: pioneering innovation regarding magnetoencephalography (MEG), and transcranial magnetic stimulation (TMS). Beside this clear and outstanding focus, the group pursues several other excellent projects in the field of optical imaging and magnetic resonance imaging, for example. The work is highly multidisciplinary, connecting with clinical work (pre-operative assessment in neurosurgery), psychology, and cognitive science. The department has established a highly impressive network of international cooperation with excellent partners in research institutions/universities, especially concerning electromagnetic techniques (MEG, TMS), underscoring their leadership position in these areas. Researchers in the department have obtained four ERC grants during the assessment period (2013-2017), which is very remarkable given the size of this department. Several highly successful companies in the field of electromagnetic methods have come out of the department, and this process has continued in the assessment period structured by the 'Biodesign Finland' activity, which is coordinated by the department. Researchers in the department are known for their presence in relevant international (editorial) boards and important committees. This department at Aalto University (in cooperation with the hospital) is a perfect choice for a seven Tesla MRI system (none in Finland, so far) and is highly encouraged to pursue its acquisition.





Field: 3b
Engineering

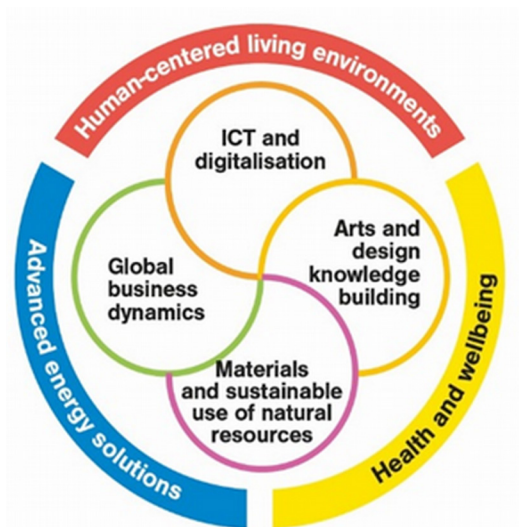
Kamal Sarabandi, Chair; Carlos Guedes Soares;
Rachelle Alterman; Daniel Loucks; Paulien Herder;
Ragnar Larsson; Phill Dickens; Oliver Brand;
Marcian Cirstea; Jan Wikander; Choongsik Bae.

Field Description

For purposes of the 2018 RAI assessment, the field of engineering at Aalto University is defined as comprising the departments of Built Environment, Civil Engineering, and Mechanical Engineering in the School of Engineering, and the departments of Electronics and Nanoengineering, and Electrical Engineering and Automation in the School of Electrical Engineering. The field consists of approximately 110 professors pursuing excellence in 19 research groups.

The operating environment of the field of engineering has changed considerably during the past five years: this includes a steady decrease in the available basic funding from the Ministry of Education and Culture and dramatic reduction in the research funding opportunities available through the field's largest funding source, Business Finland (formerly Tekes). In addition, more than 50% of the senior academic leaders, that is, professors, have changed during the same period. In spite of these challenges, the overall development of the field has been very positive. All academic KPIs have improved, and a team of excellent new professors has been recruited that will help form the foundation of Aalto University for the next generation. Furthermore, diversity of academic faculty and staff has increased, and funding from the Academy of Finland and foundations has developed.

Field of engineering professors in Aalto University focus areas



Human-centered living environments:
31 professors (Aalto total: 46)

Advanced energy solutions:
22 professors (Aalto total: 25)

Health and wellbeing:
5 professors (Aalto total: 23)

ICT and digitalisation:
18 professors (Aalto total: 91)

Arts and design:
2 professors (Aalto total: 37)

Materials and sustainable use of natural resources:
21 professors (Aalto total: 93)

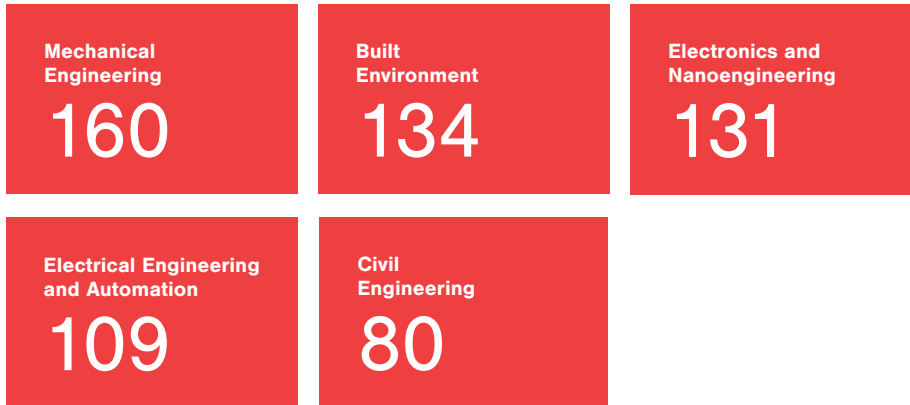
Enabling areas:
4 professors (Aalto total: 28)

In recent years, the field of engineering has designed and implemented an organizational and administrative structure that better supports a tenure-track system and Aalto's goal of research excellence. This includes both larger departments and larger thematic teams that share experimental infrastructure and jointly plan and execute educational programmes. We have taken significant steps towards encouraging professors to think beyond individual projects towards defining a personal 'field of excellence', which, in turn, supports team-wide excellence.

The field has taken great strides in developing education at all levels, from BSc to DSc. This effort has engaged all of our professors, lecturers, and learning support staff for nearly six years and has required revision of virtually all courses and educational programmes. Prior to this renewal, some professors were responsible for as many as ten courses. The total number of courses has been reduced to a manageable 2-3 per professor and about four per lecturer. Learning objectives, teaching methods, course assessment methods, and course requirements have been updated. Education programmes have been designed in consideration of the Plan-Do-Check-Act quality cycle, which allows us to identify and develop courses that require additional resources or new education approaches. Fewer courses with higher quality helps support Aalto's education goals and allows professors and lecturers more time for research. Sabbatical leaves, which used to be very difficult to arrange due to heavy teaching loads, are now a regular element of career planning for a professor.

The field of engineering has been making good strides to strengthen its doctoral education. Entrance requirements have become stricter, research and supervision plans have become more systematic, and publication practices have improved. The result is that study times for full-time students have shortened, and the number of graduates earning a DSc in engineering has almost doubled since 2012. The field is now giving attention to providing doctoral candidates with mature professional skills that complement their excellent research capabilities. Many graduates from the DSc programmes in engineering and electrical engineering are well-placed to develop academic careers. However, the goal of our doctoral education is not only to educate researchers and future professors, but also experts and game-changers for the engineering industry and public sectors. Our goal is to help develop individuals who can solve challenging problems using scientific methods and act as pioneers in technological development.

To better profile its research activities, the field has closed several large research facilities while investing heavily in internationally unique research infrastructures. The largest cleanroom facilities in the Nordic countries can be found at the Micro- and Nanotechnology Centre, Micronova. The 14 meter telescope at the Metsähovi Radio Observatory is a unique and internationally notable research facility. The Aalto Ice Tank has gained attention because of its dimen-

Academic Staff Headcount by Department

sions and, in particular, its large width. Other major research infrastructures in the field include Electronics-ICT, ePower Hub, and Metrology Research Institute. Aalto i3 – Aalto Industry and Innovation Infrastructure – is a space for students, researchers, and companies to innovate and co-create smart, connected products and services. The Aalto Design Factory is a spearhead project and one of the first physical manifestations of Aalto University encouraging and enabling fruitful interaction between students, researchers, and professional practitioners from diverse disciplines. The Design Factory concept has now been franchised in more than 20 locations around the world.

Future potential

A crucial element of developing future potential is to take a long-term perspective on each and every professor recruitment. The lack of a professor in some particular discipline may create departmental challenges for 1-2 years, but this is relatively short when one considers that each tenure track recruitment is a 20-30 year investment. New professorships are opened after careful analysis of the operational environment and assessment of the potential in the suggested research area. In the field of engineering, future industrial relevance is also an important consideration when opening a new position.

In late 2015, the Board of Aalto University approved the revised university strategy, *Shaping the Future*. This was a response to the rapidly changing operating environment of predominantly publicly funded higher education in Europe and is a reflection of what the university had learned during its first six years as a spearhead for renewal of the entire Finnish higher education system. In September 2016, the School of Engineering and the School of Electrical Engineering published their strategic plans (Roadmap 2017-2020), which represent

the vision and statement about how they will implement and contribute to Aalto's overall strategy. These documents encompass approximately the vision for building the field of engineering.

In the roadmaps, the field identifies 19 'excellence areas'. Currently, we estimate that most of these areas truly operate at an excellent international level. For those groups that have undergone major turnover of key personnel, the roadmap expresses a vision and path towards international excellence. The field of engineering is on a very good trajectory that several more groups could be in this international excellent category by 2023, while all other groups should be at a very good international level.

By its nature, engineering has always had strong elements of multi- and interdisciplinaryity. Multidisciplinarity has been actively advanced and supported across Aalto University. The various Aalto Platforms contribute to this goal. Disciplines come together to solve research challenges and address societal or industrial challenges. Aalto Industrial Internet Campus is an example of such collaboration. Aalto University is active in international research networks, such as Nordic Five Tech.

Traditionally, societal impact has been one of the key strengths of engineering research. To maintain this and to compensate for decreases in other funding instruments, engineering is actively pursuing new partnerships with companies and foundations. We expect this to allow us to increase the volume of high quality research. An industrial doctoral programmes is one of these initiatives.

New technologies in wireless communication, artificial intelligence, big data, and new materials will have a profound influence on the traditional field of engineering. These technologies, combined with systems know-how, will open numerous new possibilities for innovations and applications. Health technology, mobility, and advanced energy solutions are areas where these new technologies and innovations will have a remarkable impact.

Bibliometric analysis

In this Field 3b, almost 2 500 publications were produced in 5 years. With an estimated WoS coverage around 65%, the total output is likely higher. Furthermore, we note a strong increase of output. During 2015-2016, the number of publications amounts to more than 160% of the first period (2012-2013).

Table 6: Overview performance (output and impact) Field 3b – Engineering, 2012-2016

	Publication number	Mean normalized journal score (MnJS)	Internal coverage (IC)	Mean field normalized citation score (MnCS)	Portion of Highly cited Publications pp (top 10%)	Portion of Publications pp (collab)	Portion of Publications pp (intl collab)	Portion of Publications pp (industry)
2012-2016	2 498	1.14	0.65	1.14	0.11	0.73	0.55	0.10
2012-2013	747	1.11	0.63	1.05	0.11	0.68	0.48	0.11
2013-2014	959	1.10	0.64	1.08	0.11	0.70	0.51	0.10
2014-2015	1 168	1.14	0.65	1.15	0.11	0.73	0.54	0.09
2015-2016	1 207	1.19	0.67	1.22	0.12	0.77	0.60	0.09

The impact of this Aalto field is above world average and tended to increase during the studied period (MnCS). This also applies to the impact of journals researchers in this Aalto field published in. Simultaneously, the proportion of output in articles co-authored with other organizations, as well as the output involving international collaboration, increased. The proportion of publications involving industry is high throughout (9-10%), which fits the applied character of this Aalto field. Particularly in the departments of Electrical Engineering and Automation, Electronic Engineering and Nanoengineering, and Mechanical Engineering, the proportion of publications involving industry is high.

The research profile demonstrates a large output where researchers are involved in astronomy and astrophysics. However, if we weigh this result with the number of co-authoring organizations, this category is much less dominant.

Furthermore, the categories materials science, energy and fuels, optics, environmental science, chemical engineering, and construction and building are categories with more than 50 publications in which researchers from this Aalto field contribute and an impact 25% or more above world average. Also in this Aalto field, the output in multidisciplinary journals have a high impact.

Finally, the impact is primarily achieved in collaboration with foreign partners. Half of the output involves international collaboration, while the impact is more than 40% above world average. The impact of journals (MNJS) of output involving international collaboration is more than 25% above world average. Both MNCS and MNJS is around world average for the other types (national collaboration and Aalto only).

Research profile

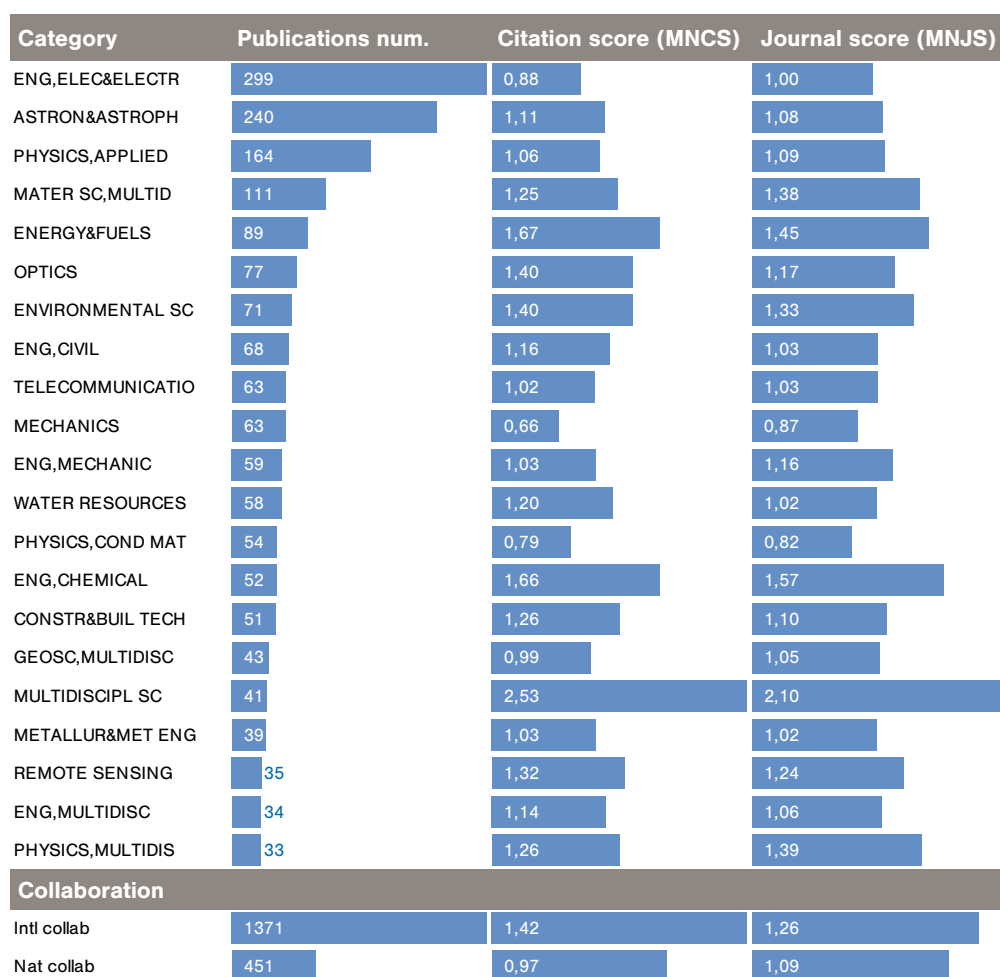


Figure 14: Research and Collaboration profile (output and impact)

Field 3b – Engineering, 2012-2016

Panel's Field Assessment

In general the departments in Field 3b are in good shape, and their progress has a positive trend. Throughout our discussions and interviews with senior and junior faculty, lecturers, postdocs, and graduate students, the panel found the research staff in Field 3b at Aalto University are happy about their environment, highly motivated, and enthusiastic about the future of their respective departments and Aalto University. This is commendable and is a reflection of proper policies at all levels of management in Engineering and Aalto University.

Recommendations on Development of the Field

Research Strategy. Develop departmental strategies for research through annual departmental retreats to create a roadmap for departments. This will help identify the focus areas in sub-fields in which the departments can attain international prominence.

External Advisory Board. Departments should be encouraged to establish external advisory boards that assist the departmental leadership in developing a focused research strategy. Such a panel can also help with lobbying, industry collaboration, and alumni fundraising. Advice of industry brings in a different perspective and is needed in undergraduate and graduate education, and it ultimately provides a link to industry.

Research Staff Workload. In terms of staff workload, make use of an academic work balancing model to achieve an appropriate balance between contributions to teaching and research, thus avoiding too much pressure on staff from multiple directions, which can affect research performance. In particular, it appears that some staff who should perhaps be focusing their work mostly on research, such as postdocs or research fellows, have significant teaching duties; similarly, it appears that lecturers – as teaching staff – are also expected to contribute to research.

PhD Student Progress Reporting. Consider introducing a system for regular (annual) evaluation/monitoring of PhD students progress by evaluators external to the supervisory team. This can be done at the departmental level by asking the PhD student and advisor to fill a short and high-level progress report that is signed by both the student and faculty and reported to the Department Chair or Associate Chair for review. This would ensure better (faster) progress of research students' research projects and should lead to earlier completion of their PhDs, thus also saving costs.

Integrated Projects. Projects that integrate BSc, MSc and PhD students across disciplines, such as the Aalto-1 Satellite project, should be considered across departments and schools as a way to excite students and involve them in research early, as well as to highlight/market university research.

Department of Built Environment

Short description of the Unit of the Assessment

The Department of Built Environment (BE) is a combination of various entities from the former Helsinki University of Technology. The National Centre of Further Education and Information Service for Regional and Urban Planning and Urban Studies was merged with the Department of Surveying in 2012, and a part of the Department of Civil and Environmental Engineering (water, environmental and traffic engineering) were combined in 2016. Given these developments, BE is multidisciplinary by nature. Extra turbulence was also created by the recession in the Finnish economy in 2009 and resulted in big reductions in university funding. Aalto staff was heavily reduced, and BE lost 10% of its personnel. Thus, the assessment period has been exceptionally turbulent in our department. Currently, BE consists of four groups: 1) Geoinformatics, 2) Real Estate Economics, 3) Spatial Planning and Transportation Engineering, and 4) Water and Environmental Engineering. BE hosts the Institute of Measuring and Modelling of the Built Environment. Regarding the Aalto strategy areas, BE is mainly connected with human-centered living environments, with exception of Geoinformatics, which belongs to ICT and digitalization.

Highlights of the department's panel assessment

Excellent multidisciplinary department with very relevant and topical research. Impact and visibility on society is impressive. The department has good potential for further scientific focus and uniqueness. High levels and quality of research in each of the sub-fields and recognition of some centers of excellence. High number of WoS publication (3 annually per tenure-track faculty member) compared to most of the peer programs with we compared with. Very impressive societal and professional interfaces by of each of the fields - national and international. The opportunities for cross-disciplinary collaboration inherent in the diverse grouping of fields in BE are clearly visible in this group's research products.

The topics of each of the groups are of growing global interest and thirsty for innovative research: New transportation technologies; changing socio-environmental urban and mobility preferences; climate change and food shortages propelling interest in water management and environmental engineering; increasing global reliance on remote sensing with crowd-sourcing. These potentially provide BE with a broad global arena to which they could expand. In addition, the recent hires of new faculty have spurred a boost in scientific impact and visibility. However, this optimistic projection depends on whether BE will be able to express its research vision and strategy, find ways to maximize the synergy of its sub-fields, and minimize the current fragmentation into small groups.

Department of Civil Engineering

Short description of the Unit of the Assessment

The department is one of the leading research units in civil engineering in the Nordic countries, continuously developing its contribution to the international research community. The department has a long history of research, education, and cooperation with the construction industry, dating to the establishment of Helsinki University of Technology in 1908. Since 2016, the department has focused its activities around design and construction of buildings and structures, including their underground applications. We also carry out experimental research to investigate physical and organizational phenomena and to validate our analytical and computational models for multidisciplinary challenges in civil engineering. Most of our professors (80%) have been appointed after the foundation of Aalto University, and many are young and enthusiastic researchers at the early stages of their tenure. The department promotes multidisciplinary research, an innovative mindset, and an entrepreneurial way of acting.

Highlights of the department's panel assessment

The department of Civil Engineering (CE) acts in a very competitive area, where the societal impact is direct. For research, the department is strategically formed around the multidisciplinary fields of building design and construction, and mineral-based construction materials. Examples of impact concern the concrete strength impact study, triggered by premature failures of concrete infrastructures in Finland. Structure safety (involving concrete) and nuclear waste disposal have societal impacts. The academic performance of the department appears to be good, both in view of number of publications and citation impact. There is a significant focus on the publication activity in the department. The department has a fair number fundamental projects and individual grants obtained in competition. The faculty and research staff are given several prizes and awards annually. The number of doctoral degrees is relatively modest for the size of the department. The number of Master's students is very large, requiring significant attention of the professors and lecturers.

The department has adequate research infrastructure and good international cooperation beyond Nordic countries. The department has limited access to EU funding as their internationally competed funding is really low (1%). They have thus a large potential of increasing this component of their activity if they prioritize it, as they should. With a young international multidisciplinary faculty, the department should witness an increase in productivity and quality of research and its marketing via new startup firms. Hence, there seems to be no reasons for the CE at Aalto not being able to achieve a world class reputation in what they do.

Department of Electrical Engineering and Automation

Short description of the Unit of the Assessment

The Department of Electrical Engineering and Automation (EEA) in the School of Electrical Engineering is a multidisciplinary ecosystem of applied scientists and engineers joining expertise from many fields of electrical engineering, automation, and ubiquitous electronics. EEA's interdisciplinary team will expand scientific and technological knowledge, and we develop methods and systems for widespread applications for industry and wellbeing. EEA's mission is to contribute to society through research, education, and innovations at the highest international level.

Highlights of the department's panel assessment

Excellence, high quality, and good volume characterize research in EEA. It gives a very good impression overall. The panel found both past and planned research is of very high quality. Considering the growing fields of robotics, autonomy including autonomous vehicles, this appears to be an excellent combination of fields for the future. The department is home to 29 faculty, of which 17 are tenure-track or tenured professors. Approximately 50% of the funding is competed research funding, with 10% from international sources, including 18 EU funded projects. Notably, the department collaborates in 2 European FET Flagship projects. The areas of focus in EEA show excellent research in a wide range of multidisciplinary collaborations and hosting centres of excellence. Very good performance is evident in terms of refereed outputs (papers). There is a high volume of outputs in high-quality publications, mostly journals of high impact. However, two aspects need to be flagged: the inclusion of a range of peer-reviewed conference papers is to be noted, and the MNCS (mean normalised citation score) is a bit less than 1.0 (representing the world average, where not world average should be the goal but a value compared to comparable institutions). EEA has large number of industry collaborations, but mechanisms for measuring/monitoring the impact should be identified and put in place. EEA has a very strong base and high potential to produce outputs of the highest level of excellence and to generate research growth and innovation. The department should strive to limit its focus to fewer sub-areas of EEA for further development, aiming to be at the forefront in those topics. Establishing a clearer identity and role for Computing in Engineering could perhaps be considered. Currently, it is seen as an integral part of various areas of electrical engineering and automation, which means that it may not be as visible (explicitly) as it could be.

Department of Electronics and Nanoengineering

Short description of the Unit of the Assessment

The Department of Electronics and Nanoengineering carries out comprehensive and cutting-edge research and teaching in electromagnetics, micro- and nanotechnology, microelectronic circuit design, radio science and engineering, semiconductor and quantum physics, photonics, and space science and technology. The department has about 160 personnel, including 18 professors. The research categories range from pure basic research to applied research done in close collaboration with national and international industry partners. The majority of our research topics is focused on experiments, and the department utilises several large-scale infrastructures: Micronova and its clean room for microdevice fabrication and nanomaterial research, Metsähovi Radio Observatory for our space activities, and Electronics-ICT infrastructure, including MilliLab for microwave, wireless communications and electronics research. We are research oriented, which is shown in a large number of publications/patents and doctoral degrees of high societal and scientific impact.

Highlights of the department's panel assessment

The areas of focus in the Department of Electronics and Nanoengineering in micro- and nano-electronics, radio/telecommunications engineering, and space science and technology show contemporary and impactful research of excellent quality, with many high-quality multidisciplinary projects. The department benchmarks itself against excellent institutions and, in terms of citations per publication (9.5), compares very well with ETH Zurich, TU Munich, Royal Institute of Technology, and TU Denmark. This is considered excellent. More than 50% of the funding is competed research funding, with 10% from international sources and about 8% from industry. The department has strong collaborations with industry, successful startup companies, and its graduates are successful in industry and academia both in Finland and outside. It has excellent infrastructure (core facilities) that are internationally competitive (e.g., Micronova). The department has outstanding faculty with very timely research topics.

The department has a very good reputation in the field and has made efforts to recruit very good, young faculty. As the field is expanding in other directions, the department can benefit by adding new faculty in emerging areas. An overall long-term strategy for the department should be developed to chart out the path forward.

Department of Mechanical Engineering

Short description of the Unit of the Assessment

The Department of Mechanical Engineering (ME) was formed at the beginning of 2016 by integrating three formerly independent departments: Engineering Design and Production, Applied Mechanics, and Energy Technology. In education, ME is responsible for two Master's programmes: Mechanical Engineering and Advanced Energy Solutions. The department also strongly contributes to teaching in the school-wide bachelor's programme and especially in its major, Mechanical and Structural Engineering. Research in the department is organized into seven research groups. Five of these are primarily associated with mechanical engineering: engineering design, production engineering, engineering materials, solid mechanics, and marine technology. The other two cover energy technology: energy efficiency and systems, and thermodynamics and combustion technology.

Highlights of the department's panel assessment

The department has good stature and reputation and very unique opportunities to leap forward as regards to attaining a very high internal reputation. The focus on marine engineering and energy are areas in which the department can focus and enhance. The number of faculty in these areas can be improved going forward. The transformation since the beginning of Aalto has been very large, and considering the amount of work in just the organizational change, they have done some very good work and are on an upward trajectory. However, the department still needs to develop a clear vision and strategy for advancing the quality of its research so that it is internationally regarded as a leading department. The industry involvement and impact is high, but it would be very useful for the department to spend more effort in demonstrating the actual level of impact. The department is organized into two major areas, namely, mechanical engineering and energy technology. The department's excellence is evident primarily through three prominent research areas: energy efficiency and systems, production engineering, and marine technology (despite the number of professors in this area being too low). There is a high focus on publications - 9.5 refereed journal papers per professor is a very high number, and clearly the professors have a high output compared to other universities. The high technology readiness level research funding is very high at about 58%, which shows that the department is biased towards application research rather than more basic work. Overall, the percentage of international funding (3.9%) is very low, and it would be expected to be much higher.

Case study: Aalto-1, the first Finnish satellite

VIDEO: <https://youtu.be/wlZ6lEsy9e4>





Field: 4
ICT and Mathematics

***John Lafferty, Chair;** Muffy Calder; Marta Kwiatkowska;
Maria Sabrina Greco; Thushara Abhayapala; Susanne Boll;
Sjaak Brinkkemper; Marta Sanz-Sole; Andrew Odlyzko.*

Field Description

In the RAI 2018 assessment, the field of ICT and Mathematics at Aalto University consists of departments of Communications and Networking, and Signal Processing and Acoustics in the School of Electrical Engineering, and the departments of Computer Science, and Mathematics and Systems Analysis in the School of Science.

ICT and digitalization is one of Aalto's four core competence areas, and these four departments with altogether 68 professors and total academic personnel of more than 500 form the mathematical and methodological backbone of this competence. In addition, there are about 40 professors in several other departments working with topics of ICT or closely related fields. Furthermore, the professors of these four departments contribute strongly to all other core and applied research areas at Aalto University (*Figure 15*), and the multidisciplinary nature of the research is evident from the range of fields of the journals in which the professors publish their results, for example.

The departments of Field 4 focus their research in the following sub-fields: algorithms, logic and computation, complex systems, data science, big data and digital health, signal processing and acoustics, distributed systems including communication systems, internet technologies, mobile computing, security and privacy, human-computer interaction, games and graphics, machine learning, data mining and probabilistic modeling, software and service engineering, operations research, statistics, stochastics, and mathematics.

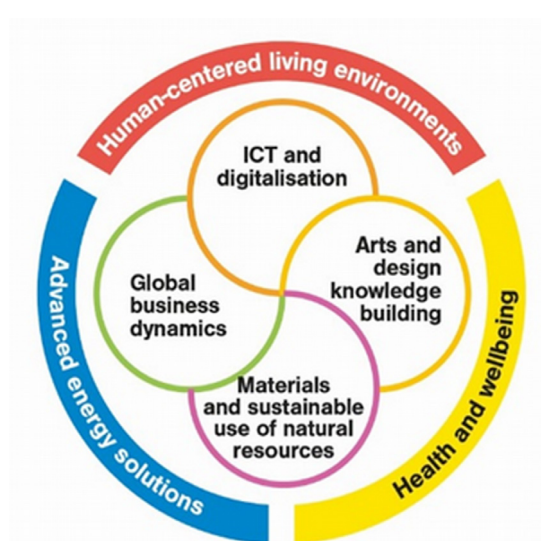


Figure 15: Aalto University's four core competence areas and three multidisciplinary themes.

During the assessment period, the field at Aalto has undergone major organizational changes, the most significant of which being the merger of three departments, Computer Science and Engineering, Information and Computer Science, and Media Technology, as a single Department of Computer Science in the beginning of 2015. In addition to organizational renewals, several research groups in the field have relocated to the Otaniemi campus to foster collaboration over department and school borders, for example, the acoustics and audio technology researchers from both departments of Computer Science (SCI) and Signal Processing and Acoustics (ELEC) moved to the same building. Furthermore, the faculty has been largely renewed with retirements of some highly productive pioneers of the field (e.g., Erkki Oja) and recruitment of approximately 30 new professors on tenure track, mostly young talent at the assistant professor level.

Considering the major renewal of both the organization and the faculty, development of the field at Aalto has been very positive during the assessment period, manifested by the rapid rise of Aalto in the field-specific international university rankings (*Figure 16*). Several ERC Starting grants secured by young professors of the field (Parinya Chalermsook, Petteri Kaski, Tapio Lokki, Ville Pulkki, and Antti Oulasvirta) are proof of successful recruitment of young faculty. Research groups in the field have coordinated or participated in several Academy of Finland Centres of Excellence during the evaluation period: Computational Inference Research (coordinator), Algorithmic Data Analysis Research (partner), Molecular Systems Immunology and Physiology Research (partner), Research on Solar Long-term Variability and Effects (partner), and Inverse Modelling and Imaging (partner). Furthermore, several senior faculty members hold Academy Professor positions (Paavo Alku, Samuel Kaski, and Visa Koivunen).

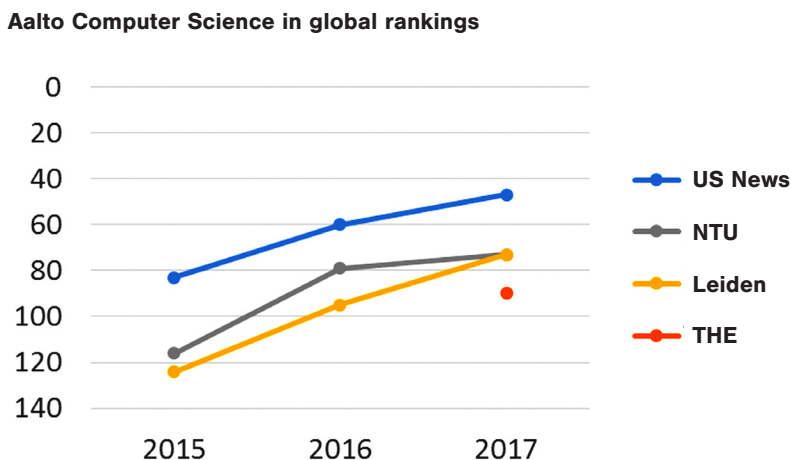


Figure 16: Development of Aalto Computer Science position in global university rankings.

The ICT and mathematics field at Aalto has a long tradition of industrial cooperation with a large number of Finnish and international companies, like ABB, Nokia, and Saab. Furthermore, the excellent research of the field has resulted in several technology transfers and spinoff companies, as listed in the departments' self-evaluation reports. In addition, the departments cooperate with the Finnish Defense Forces, and the faculty assists the government in decision making via several positions of trust and reports commissioned by the ministries, and by participating actively in public debate.

Collaboration with other Aalto units and Finnish universities, as well as with industrial partners, is fostered via the professors' active participation in several strategic initiatives within Aalto University (Digi Platform and other Aalto platforms, Aalto Centre for Operations Research) and beyond (Finnish Center for Artificial Intelligence (FCAI), Helsinki Institute for Information Technology (HIIT), Helsinki-Aalto Centre for Information Security (HAIC)).

Future potential

Aalto is well positioned for the ongoing digital transformation. The long-term research strengths of the core ICT departments in this panel are in the critical areas driving the transformation, such as AI and data science, cyber security, 5G technologies, and signal processing. In the wider picture, over 30% of professors at Aalto are in ICT-related fields in all schools, in areas like digital business, digital manufacturing, automation, sensor technologies, digital media, et cetera.

In hardware development, quantum computing - and quantum technology in general - carry huge promises in revolutionizing computing in future. Aalto has very strong research in quantum technology (Field 3a), with increasing synergies with ICT fields. While the industrial giants invest extensive amounts of money in this area, similarly as in AI, we see considerable future potential in quantum-ICT collaboration, especially in quantum sensors and quantum communication.

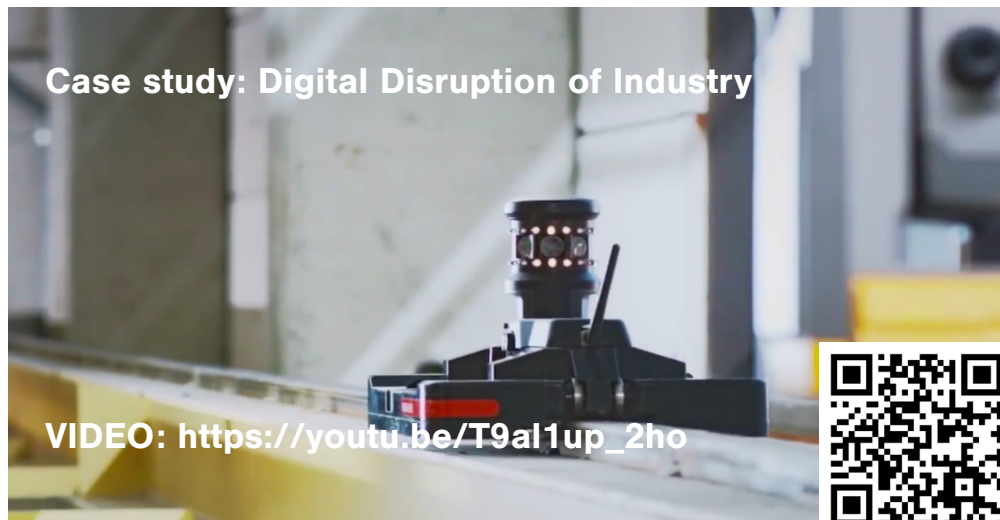
Aalto has the leading role in educating ICT experts in Finland and acting as the driving force in keeping our industry internationally competitive. Currently Aalto is responsible for educating about 40% of MSc and PhD graduates in ICT in Finland. With the recent increasing investments of other Finnish universities in ICT, Aalto should make similar strategic decisions to ensure it stays a top authority in the field and continues to produce the best education for future experts increasingly needed by the Finnish industry and society.

The field is constantly developing educational programmes to keep attracting top Finnish and international student talent. For example, we are piloting fast-track doctoral programmes with combined MSc and doctoral curricula. Also, we have established a new English bachelor programme, with strong computational emphasis, between SCI and ELEC schools. Current majors are data science

(SCI), digital systems and design (ELEC), and quantum technology (SCI+ELEC), and in future, the programme will be extended to all schools in technology. The programme will serve two purposes: to attract non-Finnish speaking talent from Finland and abroad, and to provide education with deeper math and computational skills than the general bachelor programmes.

Artificial intelligence is an ongoing and exponentially increasing disruptive transformation across society as a whole, and data science is currently in huge societal demand. Also, the Finnish government is increasing investment in this field. The research groups in this field at Aalto are world class and, in the current industry interest in AI, facing both great responsibility and huge opportunities. The impact of the field arising from applications is massive, especially in health and wellbeing and human-computer interaction. The Finnish Center for Artificial Intelligence forms a central link between academic research and AI-related ecosystems, and it will boost the AI industry in Finland.

5G (and in the future 6G) is the backbone of the *industrial internet*. Aalto University and the departments in this field are among the spearheads in developing the new technology that will result in applications that can transform what we currently understand as connectivity. The Aalto Industrial Internet Campus (AIIC) is one of the manifestations of the importance of the field. AIIC brings students, researchers, and companies together to innovate and co-create smart, connected products and services.



Bibliometric analysis

The internal coverage shows that research for this Aalto field is reasonably covered by the WoS (0.57). The volume of output increases at a normal rate regards primarily increased collaboration rates (both national and international). The impact fluctuates strongly over the years and is always well above world average (both MNCS and PP[top10%]). Finally, we notice a good proportion of output involving industry. On top of that, we found a large variation among departments for this indicator. In the departments of communications and networking (PP[industry]=0.16) as well as signal processing and acoustics (0.12), the proportion of output involving industry is well above the others in this Aalto field (Annex C: Bibliometric Profiles of departments).

Table 7: Overview performance (output and impact) Field 4 – ICT & mathematics, 2012-2016

	Publication number	Mean normalized journal score (MNJS)	Internal coverage (IC)	Mean field normalized citation score (MNCS)	Portion of Highly cited Publications PP (top10%)	Portion of Publications PP (collab)	Portion of Publications PP (intl collab)	Portion of Publications PP (industry)
2012-2016	1,784	1.27	0.57	1.29	0.13	0.77	0.60	0.08
2012-2013	589	1.20	0.56	1.20	0.12	0.73	0.53	0.09
2013-2014	695	1.30	0.56	1.39	0.13	0.75	0.57	0.06
2014-2015	776	1.37	0.57	1.46	0.14	0.77	0.63	0.08
2015-2016	796	1.29	0.57	1.23	0.13	0.81	0.65	0.09

The impact of all categories in the research profile is at a similar high level. In some very general categories (multidisciplinary, and physics - multidisciplinary), the impact significantly exceeds the average of the Aalto field. The key category in this Field is electrical and electronic engineering with the largest output and an impact at 40% above world average. Other categories with more than 50 publications and an impact of at least 1.25 are computer science – AI, and theory and methods, and acoustics. Furthermore, neuroscience is worth mentioning with less publications but an impact almost twice world average.

Almost all publications in multidisciplinary journals in this field are published in PLOS ONE, that is, Open Access. The high proportion of output involving international collaboration has positively influenced the high impact considerably.

Research profile

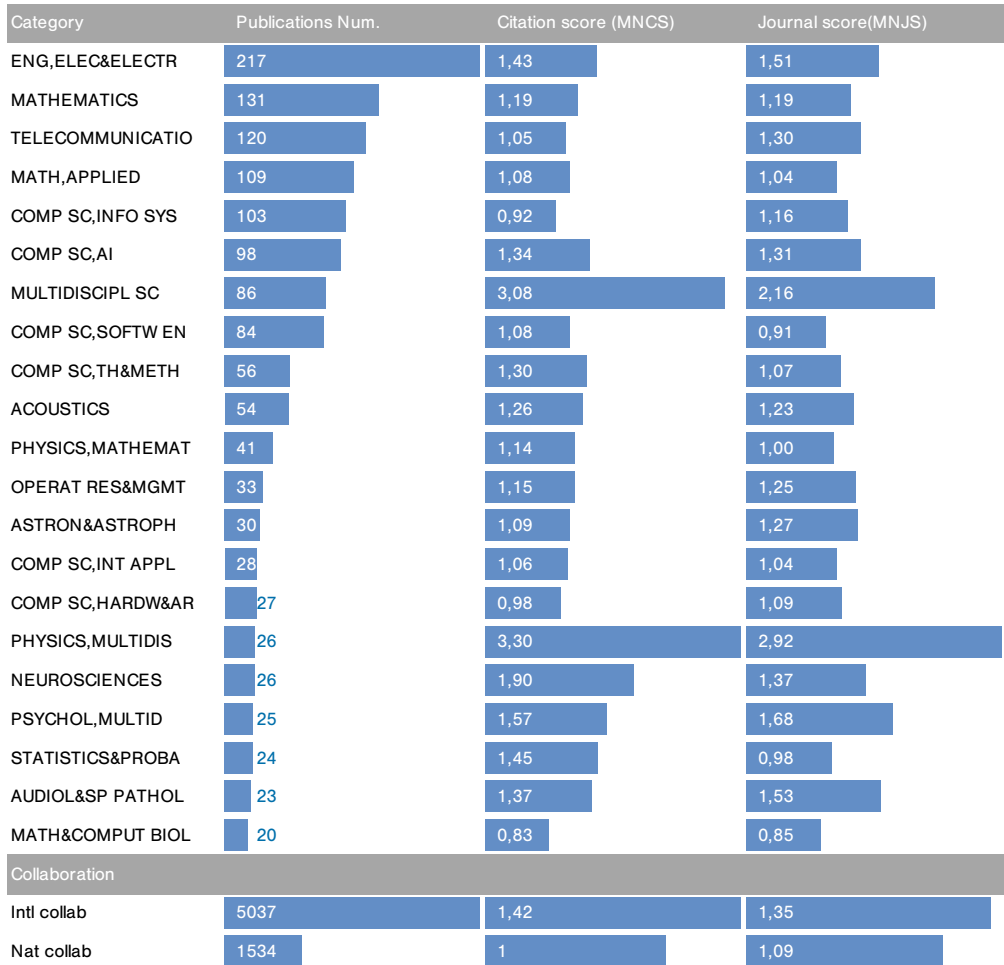


Figure 16: Research and Collaboration profile (output and impact)
Field 4 – ICT and Mathematics, 2012-2016

Panel's Field Assessment

The four departments comprising Field 4 have excellent track records for research excellence and impact. Each of the departments has a strong faculty, including senior faculty and junior faculty, with recognized international leaders in multiple areas. The committee was extremely impressed with the accomplishments of the departments, not only in terms of the fundamental research as evidenced by the publication and grant activity, but also the successes in attracting new faculty and students, and connections to companies and government agencies. The atmosphere within the departments is highly conducive to research success, and faculty and students appear to be happy and energized. Field 4 departments have some remarkable research strengths, which have attained excellence at an extremely high international level, notably in machine learning, and in areas of signal processing. The future of the field is exciting and promising, and they will surely continue to strengthen the global visibility of the university.

Based on the presentations, meetings, and side conversations, the panel participated during the site visit. With the reports that were carefully prepared by the departments, the panel formulated a few suggestions that might help to continue the success of the departments - particularly in times of increased competition for people and resources within the global research community. The panel identified four main areas for consideration: organization, hiring, diversity, and multidisciplinary fields.

Organization

Aalto University has a very unique makeup, which is due to the historical merging of universities, and the active choice to specialize in selected fields. The university has been remarkably effective and successful, noting that in many ways it has only existed for about eight years. The committee felt that the organizational structure of the departments in Field 4 deserves attention, including both the way that technical disciplines are grouped, and the manner in which the departments organize their activities.

Introduce a system that provides better management of departmental records. During the presentations and our discussions with department heads and deans, it appeared that quantitative information concerning PhD students, startups, alumni, and other 'products' of departmental activity were not readily available. For example, basic statistics on the number of startups and graduates were not known. We recommend that a management system is introduced that enables better organization and use of these data. This is important for a number of reasons. Alumni networks can be very important to the departments,

the university, and the alumni themselves. When a startup or former student is very successful, the departments and university should receive appropriate recognition. These data can also be helpful in recruiting, preparing departmental advertisements, et cetera. Once a good system is in place, it should be somewhat easy to maintain.

Reorganize the departments in a way that better recognizes and leverages shared research strengths. In this RAI assessment, there were four departments in Field 4 ICT and Mathematics. They share common intellectual foundations and goals, with potential for significant collaboration. This is increasingly the case with technical developments in areas like machine learning that cut across many disciplines. Yet two of the departments are in the School of Science (Computer Science, and Mathematics and Systems Science) and two of the departments are in the School of Electrical Engineering (Signal Processing and Acoustics, and Communications and Networking). In our interviews, several faculty commented that a reorganization that brought these and other departments closer together would be welcome. An improved organization would leverage and amplify the expertise that is spread over departments and schools.

Hiring

The recruitment, hiring and support of faculty is central to the mission of any top research university. Aalto rightly invests tremendous energy and resources for recruiting the best researchers in the world. In the current global research atmosphere, where competition for top talent is intense in areas of focus at Aalto, it is more important than ever to pay attention to the details of the faculty recruitment and retention. To this end, the committee makes the following recommendations.

Introduce more streamlined and efficient hiring procedures. There can be a long time between a faculty candidate's interview and an official offer being made by Aalto. This may not be best for successful recruiting of the strongest candidates, particularly in the current environment of intense competition for the best young researchers. The current system has a high overhead in terms of the investment of time by faculty to serve on committees and complete paperwork that is required before an offer can be made. The level of effort was viewed as significantly greater than what the committee members see at their own institutions. For example, the role of the teaching committee was unclear. To the extent possible, we recommend that the field and university work together to make hiring more efficient to be able to aggressively pursue the top people in the field.

Continue and strengthen the current tenure system and offer structure.

The committee was very impressed with the uniform enthusiasm and support for the tenure system that has been adopted by the university. The faculty feel that it is working well and that it offers a clear and transparent career path. It is viewed as a competitive advantage over peer universities in Europe. Moreover, junior faculty expressed strong support for the flexibility of the startup packages that they have received, which are key factors in both accepting offers and in successfully jump starting their academic careers - exactly the intention of these packages. This structure should be continued and even enhanced in the future. Finally, incentive structures, including partial return of overhead to the primary investigator of an externally-funded grant and financial rewards for JUFO3 articles, are effective policies. We enthusiastically encourage adding more creative means for incentivizing the highest quality research.

Improve mentoring of junior faculty and postdocs. From interviews with faculty and postdocs, the panel learned that several mentoring efforts are in place, but they vary from department to department. Mentoring is very important to the careers of all young researchers, even if it is difficult to prescribe what good mentoring exactly is. If not required already, a written mentoring plan should be prepared for each postdoc and assistant professor, which is reviewed periodically to see that the goals are being met. Mentoring can include a very broad range of information: from professional goals like preparing presentations, to technical issues like grant writing, advising, and teaching, to such personal concerns as work/life balance, language learning for international researchers, and child care. Mentoring may need to be tailored to reflect special needs of women (see below).

Support hiring of fixed term staff and instructors. Many research projects in the ICT disciplines have a need for software development. While much of this can be justified as part of a doctoral student's research, oftentimes extensive software is required that delays the scientific agenda when done by the students or posdocs on the project. In such cases, it would be best to hire a programmer to work with the researchers for a fixed term. The time period could range from a couple of months to one or even two years. The committee learned that such fixed-term contracts for programming are not common at Aalto. We recommend that the ability to hire programmers (or other technical staff) could provide a significant advantage to the Field 4 departments, and that the field and university together explore possibilities for such positions, which are very common in departments across the United States, for example.

A related concern comes from teaching demands, particularly in the Department of Mathematics and Systems Analysis. Naturally, instruction in mathematics

is central to the educational goals of many disciplines, and mathematics departments will be privileged - and burdened - with providing this education. When the burden is placed on tenure track faculty, it will necessarily take away from research efforts. In many countries, in particular the US, this is successfully addressed by fixed-term instructor or assistant professor positions. These are often prestigious, highly competitive, and sought-after positions. We recommend that Aalto studies the possibility of introducing more fixed-term positions for teaching and research in this type of model.

Strengthen the interface between the departments and administration with respect to hiring. In conversations with faculty from Field 4, the committee learned that in recent years, several hiring cases that were approved at the department and school level were ultimately turned down by the administration. This is not good for the morale of the faculty, who are so heavily invested in the recruitment process. Ultimately, the faculty within a discipline have the greatest information and judgement for recommending faculty appointments. If they are overturned, these decisions should be transparent and justified to preserve the mutual trust and respect that is important within the university.

Diversity

The departments in Field 4 have presented their efforts in recruiting female scientists, and have shown some success and serious concern and attention to the issue of diversity. Overall, the current levels of diversity are comparable to what is found in related fields throughout engineering and applied science, including computer science in Europe and the US. Nevertheless, the participation of female researchers in the group of tenured and tenure track professors is unacceptably low. In our discussions with Field 4 members, the panel heard that recruiting women is challenging and that opening positions only for women is not possible according to Finnish Law. In different discussions with the departments, we found that, while there is a general willingness and desire to increase the number of women in the departments and schools, the culture of diversity at Aalto could be greatly improved, leading to better outcomes for equality and ultimately excellence in research. The panel offers a set of recommendations toward this goal.

Develop an active recruiting policy. Before any opening in certain fields, the departments need to collect a list of female researchers who could be asked to apply. In general, the department should actively get in touch with postdocs all over the world and invite them to visit and give a talk in Aalto. This will allow the department to get in touch with the researchers and also introduce the environment of Aalto to them.

Practice a greater awareness of diversity issues. There should be a commitment to adhere to good practices for gender equality and diversity, representing Aalto to the outside. A quick look into examples of special issues and books involving Aalto researchers suggests to us that all editors have been male. It would be good to raise awareness that diversity and gender equality is not taking place on the level of recruitment, and this is affecting many of the research and scientific activities of all members of the department. Projects, publications, seminars, and conferences with participation of Aalto researchers are the face of Aalto to the world. Consider the image that is being projected with respect to diversity.

Improve mentoring of women in technical fields. The university together with the departments should develop a mentoring concept for women in Engineering and Computer Science, for PhDs, postdocs, and faculty. The mentoring concept can cover scientific mentoring, management mentoring, presentation and communication strategies, life/work balance and many other aspects that are important to developing a successful career. An assigned (female) mentor can meet them regularly and expose them to different aspects of research and teaching such as paper writing, conference visits, and career development. Even though these women may leave Aalto, this will be an investment that can improve the representation of women in computer science, engineering, and science. Moreover, it will contribute to improving the image of Aalto with respect to diversity, leading to better outcomes for recruiting. There could be a women's lunch every term, spanning many fields, where women are invited to discuss research and academic careers on the invitation of the president.

Provide improved monitoring of activities related to diversity. For RAI 2018, the departments have collected statistics related to women in the departments. The university, schools, and departments should carefully set up a system in which the number of women and their activities are monitored to document the status of diversity efforts. This can be a part of the management system already discussed above. For example, information could be made available on how many hours women have participated in internal committees in comparison to their male colleagues, the durations of PhDs, and so on.

Provide better support for dual careers (2-body problems). It is not uncommon that a candidate's decision to accept or reject an offer depends crucially on the career opportunities of a partner. Such considerations therefore impact the success of recruiting efforts very significantly. When recruiting a candidate that would improve the diversity of the university, it is essential that

close attention is paid to opportunities for a spouse or partner. The university may consider developing a strategy for addressing such 'two-body' problems. Even though this is a challenge worldwide, the university should consider if dual-career hires are appreciated at Aalto and how to establish such a process. Both formal programmes, for example an office devoted to dual career concerns, and informal efforts, for example providing networking to local companies, can have an impact on improving diversity.

Multidisciplinary fields

Several multidisciplinary themes are prominent across the university: living environments, energy, and health and wellbeing. These broad and ambitious initiatives in some ways represent the best of Aalto's past and future. They will require truly interdisciplinary efforts, integrating the core of the university's strengths in art/design, business, and science and technology. The university is to be applauded for its ambitious efforts toward societal relevance. However, the committee found reason for concern about these multidisciplinary efforts because they are not well-integrated into the research agendas and incentive structures that are present in the academic departments. There is tremendous potential for these initiatives, yet they are in the early stages. We have the following suggestions regarding the multidisciplinary fields.

Provide increased incentives. The committee perceived a disconnect between the schools or departments and the university perspective concerning these broad multidisciplinary fields. The themes appear to be part of the 'corporate identity' or 'brand' of the university and have the potential to leverage the strengths in art, business, and science. Yet, the incentive structure for participating in these multidisciplinary themes does not always align with a unit's research goals. There may be a tension between the goals of excellence in the traditional disciplines of the tenure-track faculty and societal impact through the formation of 'meta-disciplines'. The university should explore ideas for better aligning these goals.

Secure increased university-level funding for the cross-cutting themes. The committee recognizes the challenges involved in funding multidisciplinary research and development. However, funding will be an effective way of ensuring that the departments' deep expertise and capabilities for innovation will contribute to campus-wide themes. Aalto might explore fund-raising campaigns from a combination of private foundations, individuals, government agencies and other sources. Creating competition for these resources through internal proposals could be one way of better aligning the core research with the cross-cutting themes, and better distributing ownership for their success across

the departments. Aalto might consider carrying out case studies of similar efforts at other institutions. One such example is the Cornell Tech campus in Manhattan, part of Cornell University that is taking a non-traditional approach to embedding university in an urban environment to have direct societal impact.



Department of Communications and Networking

Short description of the unit of the assessment

The Department of Communications and Networking (Comnet) carries out research in the areas of information and communications theory, communications and networking technology, and the communications ecosystem. Comnet combines the research traditions from electrical and communications engineering with computer science, economics, and cognitive sciences. With 11 tenure-track professors and 5 other professors, Comnet is well positioned to approach research and teaching in communication and networking in a comprehensive fashion, covering all the Open Systems Interconnect layers, from physical to applications and angles, and from technology to economics and user interfaces.

Highlights of the panel assessment of the unit

The department has a strong track record of scientific achievements in the communications and networking domain. It carries out basic research as well as strategic, multidisciplinary projects in applied contract settings. The basic research on existence of q-analogs has some potential in the design of future efficient data transmission. The strategic research on device-to-device communications is quite well known internationally and has produced many well-cited papers. The strategically new direction of computational interaction led by Prof. Oulasvirta has attracted an ERC Starting Grant. There is adequate emphasis on multidisciplinary in some of the research activities conducted by the department, particularly on network economics and on virtual reality applications. Moreover, the applied research is very well received, as proved by the many excellence awards received over the last few years. The volume of publications appears to be stable, as is the quality profile in JUFO terms (level 2 and 3). Recognition is achieved by participation in standards, technology development projects for the Finnish government, and a set of startup companies. Contract research provided the testbed facilities for further experimentation by the research groups. The hiring policies and awareness of diversity are good. The department recognizes that communication technologies are becoming a commodity and has identified a number of future research directions. Concluding, the department's research work exhibits quality that is generally internationally well received in terms of significance and rigour. The results of the research are published at international levels, though there is some room for improvement.

Department of Computer Science

Short description of the unit of the assessment

There is an increasing need for competent professionals in ICT and digitalization throughout various fields in society. The Department of Computer Science (CS) responds to this demand by providing world-class research and education in modern computer science. Our research addresses and solves challenging problems of high theoretical, practical, and societal relevance. CS is the largest department at Aalto, and the largest CS unit in Finland, with 43 professors and more than 400 employees. The department covers a broad spectrum of the ICT field and have obtained critical mass in our chosen research areas, ranging from artificial intelligence (AI) and data science to security and software engineering. CS is known for high-quality research (#12 in Europe, #73 globally) and by the new research initiatives (FCAI, HAIC) and the strong ICT hub in the Helsinki region. CS attracts significant numbers of international students into our MSc and PhD programmes and produces on average over 150 Masters and 25 doctors per year. The faculty's strength is apparent in the high volume of extremely competitive funding from the Academy of Finland and the European Research Council.

Highlights of the panel assessment of the unit

The Computer Science department's research is at a very strong international level, with excellent quality and visibility. The areas of focus suit the department very well and place it strongly in the international community. The publication record and leadership activities are outstanding. Publications are in top-ranked journals and conferences in the field. The department has notable stars, professors Samuel Kaski and Pekka Orponen, and at the same time a very good number of excellently performing younger professors and academic staff. The department demonstrates clear international strength in machine learning. There is a long tradition of fundamental and applied research in AI (neural networks), which is distinctive, internationally. The department coordinated a Centre of Excellence (COIN), which has a high international profile. However, the impact through ERC grants could have been stronger: the department is missing ERC Advanced or Consolidator grants. Collaborative research with the University of Helsinki is positive. CS has very impressive employment statistics for graduates.

The highlighted key societal impact activities of the department shows that the CS has much more potential, not only for excellent research, but also to demonstrate the societal impact of their work.

Department of Mathematics and Systems Analysis

Short description of the unit of the assessment

The Department of Mathematics and Systems Analysis (MS) is the mathematical core of Aalto University. It provides valuable services in educating students of many departments and has established itself internationally with exceptional research. The research conducted in MS has received increasing international attention and makes the department an attractive workplace for young international researchers, as witnessed in recent calls for application. New recruits have broadened the scope of the department's research and helped to enhance Aalto's international visibility, as well as its network of collaborators. Shared positions with other departments will continue to strengthen collaborations within Aalto.

Through service teaching, the MS department is actively involved in many different study programmes. It constantly improves the quality of its teaching, and the very positive student feedback following the study programme reforms during 2013-2016 demonstrate its effectiveness. Students within the MS department profit from an active research environment that encourages them early on to partake in ongoing projects. Furthermore, it is at the forefront of e-learning and spearheads it nationally. In international rankings, the department has, within a short time, reached a position that is comparable to similar departments in Nordic countries, despite its smaller size. The MS department will continue this upward trend by attracting more outstanding researchers, ensuring the quality of its teaching, and educating excellent students.

Highlights of the panel assessment of the unit

The department has great potential for making an international-level impact on the research community and society, and a good potential for emerging research fields, as quantitative approaches spread to more and more fields, and mathematical methods are becoming ubiquitous in sciences and technology. The department's vision to 'establish itself as a world-class research centre in mathematical sciences, in particular in the fields represented by its research groups', sounds perhaps too optimistic, at least within the next 5-10 years, unless the critical mass of the department increases substantially or the research interests become more concentrated. Given the limited size of the department, the choice of directions is likely to be critical. New tenure-track positions in the fields of discrete mathematics and of statistics and stochastics are recommended. The research and impact outputs of the department could increase if the teaching pressure would be lessened.

Department of Signal Processing and Acoustics

Short description of the unit of the assessment

The Department of Signal Processing and Acoustics consists of four focus areas centered on acoustics and audio signal processing, measurement science and technology, signal processing, and speech and language technology that all share a common fundamental theoretical and methodological background in electrical engineering, physics, and applied mathematics. The academic staff comprises 10 tenured or tenure-track professors and approximately 70 other research personnel, including one current and one former Academy Professor, 3 IEEE Fellows, 2 Fellows of the Audio Engineering Society, and a notable number of researchers who have received highly competitive career advancement funding from the Academy of Finland or ERC. The unit has a strong emphasis on basic and applied research and researcher training, as reflected by Aalto ICT field's highest number of peer-reviewed publications, citations, and number of completed doctoral degrees when normalized by the total income or personnel headcount of the unit.

Highlights of the panel assessment of the unit

The unit is outstanding from multiple points of view, both qualitatively and quantitatively. The number of papers per professor published in top-tier journals is very high for all the areas of interest of the unit. Impressive is the number of awards received for best journal papers and conference papers, thus proving the excellence of the research carried out by this unit and its impact on the international community.

The unit's research scientific quality is excellent, and it has already generated significant interest within the international community. It is regularly published on top-level journals and conference proceedings.

This unit is internationally acknowledged as one of the leaders in the field. Some of its members are recipients of international prizes and grants. Despite its small size, this unit is very dynamic in its interaction with society, as clearly demonstrated by the case studies. The research environment of this department is very good and attractive at the European level for international experts in the field. Technically, the unit has a huge potential. The research of its members is at the forefront of the scientific activity in the field, particularly in statistical signal processing and acoustic signal processing.



Field: 5
Energy

***Paulien Herder, Chair;** Choongsik Bae; Carlos Guedes Soares;
Marcian Cirstea; Erlin Stenby; Peter Norman Sorensen;
Daniel Guide; Lisbeth Olsson; Pär Jönsson; Emiel Hensen*

Field Description

Aalto’s Energy research broadly covers different aspects of advanced energy solutions. Topics include sustainable energy production, energy storage, and conversion, power engineering, energy efficiency, energy systems and markets, and resource economics. Research excellence is found widely across different schools, for instance, in the development of new materials for energy applications. The energy research has a significant societal impact, and there are multiple externally funded multimillion-euro strategic projects on future energy systems at both national and global levels. These major research initiatives have been built on multidisciplinary, benefitting from wide technical expertise, and half of them combine at least two of the three main fields at Aalto: engineering, business, and design. Bringing together the different actors in Aalto’s energy research, the Energy Platform is the most diverse energy community in Finland. It is a light-weight organization led by a board of professors, and it initiates and supports multidisciplinary actions by facilitating the networking of researchers and offering seed funding. It recently facilitated the formation of a joint Master’s programme in energy having contributions from all six schools at Aalto.

Focus areas:

- Sustainable energy production
- Energy storage and conversion
- Power engineering
- Energy efficiency
- Energy systems and resource economics

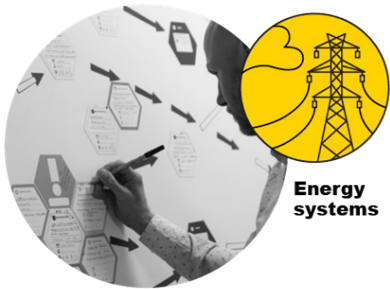


Table 8. Energy-specific figures

Publications in high IF journals (IF > 7)	186
Publications with cross-School collaboration (2013-2017)	527
Publications with ≥ 3 schools collaborating	27
ERC grants (2 AdG, StG, PoC)	4
3 Strategic Research Council and 1 big Business Finland projects coordinated by Aalto	€15m



Energy-related research is widespread at Aalto, and it has been acknowledged as the most diverse energy community in Finland: it has active contributions from science, engineering, business, and design, and it looks at a variety of energy issues, from development of nanomaterials to large-scale energy production. Aalto's energy research community consists of approximately 70 professors with 350-500 publications annually. One of the spearheads is research related to developing materials for efficient sustainable energy production, storage, and conversion. Another focal point is energy systems and resource economics, investigating and directing the development of future energy systems. Aalto also funded the €12m Aalto Energy Efficiency programme. This university-wide programme had a broad mandate: covering energy-efficient technologies for power systems and energy conversion, and environmentally-friendly technology and processes that have a higher energy and material efficiency, and thus reduce the end-use of energy. Aalto's energy research has been particularly successful in major national funding calls that are focused on strategic million-euro-level projects. There have been three Strategic Research Council (SRC) projects on energy and a large Business Finland (Tekes) project; Aalto is the coordinator in all these projects totalling €15m. Two of these four projects combine at least two of the following fields within Aalto: engineering, business, and design. Thus, the benefits of multidisciplinary within Aalto's energy research have been capitalized. The major SRC and Business Finland projects focus mostly on the transformation and security of future energy systems, both nationally and globally. These focus areas resulted in several highly cited publications between 2013 and 2017.

Excellence, Quality, and Multidisciplinary Collaboration of Research

Energy is a key research area at Aalto University, with proven excellence (Table 8). For instance, Aalto's energy researchers have obtained four ERC grants between 2013 and 2017. Prof. Maarit Karppinen has obtained two ERC grants: one Advanced grant and one Proof of Concept grant (€2.7m), both in the field of thermoelectrics. Prof. Antero Arkkio received an ERC Advanced grant (€2.5m), *Additional losses in electrical machines* (2014-2019). Prof. Hele Savin received an ERC Starting grant (€845k), *Riddle of light-induced degradation in silicon photovoltaics* (2013-2017).

Related to esteemed national funding and networks, professors Kari Laasonen and Patrick Rinke were part of the Academy of Finland Centre of Excellence in Computational Nanoscience (COMP, 2012-2017), and the Academy has also funded three energy-related SRC projects (€13m). COMP and the SRC projects are led by Aalto. A particular merit is Aalto's success in the funding call for the New Energy programme by the Academy of Finland in 2014: Aalto's share was more than 40% (i.e., >€4m) of the total granted funding for the entire country.

The articles published in the highest impact factor journals focus on energy materials. Interestingly, 68% of publications in the very highest-impact journals (IF>15) are in the field of solar energy. Whilst the focus is on solar energy, there is a wide range of publications in that area, covering silicon solar cells, dye solar cells, perovskite solar cells, and solar water splitting (i.e., solar fuels). Many of the highest-impact works have internal collaboration combining specific know-how in materials and manufacturing (e.g., carbon nanostructures, printing) with research excellence on such applications as solar cells, having contributions from three Aalto schools (SCI, ELEC, CHEM). Besides local networking, the groups publishing in the highest-impact journals have active international collaboration with top-ranking universities, including Massachusetts Institute of Technology (USA), École Polytechnique Fédérale de Lausanne (EPFL, Switzerland), and Imperial College London (UK). Other research areas featured in high IF journals (IF>7) that cover materials development for energy applications, such as thermoelectrics, fuel cells, and supercapacitors. Between 2013 and 2017, Aalto's energy researchers produced ten publications in *Nature* journals (*Nature Nanotechnology*, *Nature Photonics*, *Nature Physics*, *Nature Communications*) and six publications in the highest-ranking journal in the field of energy and fuels: *Energy & Environmental Science* (IF 29.5).

The Energy Platform gathers people from within and outside the university to tackle multifaceted problems with significant societal relevance. The platform provides a forum of networks for Aalto faculty, as well as visibility and easy access to collaboration for stakeholders. The platform is lightweight in structure, led by an academic board of professors. Aalto provides resources for the platform chair and a senior-level manager, and offers seed funding for mobility and research initiatives. While researchers remain employed in their departments, everyone is welcome to join the activities. The Energy Platform organizes thematic breakfasts, seminars, and other events to facilitate multidisciplinary. The events have gathered around 300 participants annually. In 2017, the number was roughly doubled because the platform events were further developed by covering a wider range of topics and targeting more networking with industry. Seed funding (annually about €800k for all platforms) available through internal calls has led to the initiation of larger programmes and resulted in successful funding applications to national and international funding organizations. The multidisciplinary collaboration is not limited only to research: one major outcome has been the development of a joint Master's programme, Advanced Energy Solutions, connecting all six Aalto schools by the beginning of 2018. The Energy Platform has also arranged events and training to promote and thus increase the visibility of energy research.

Impact of the Research Activities on the Research Community

When looking at excellence in terms of citations, multiple examples can be found in publications in high-impact journals, as described in the previous section. Regarding keywords related to Aalto's publishing in terms of energy, the field is clearly split: energy systems and energy materials. This can be seen in the analysis of the most common keywords, where 'systems' pops up as the most used keyword (*Figure 17*). There is also a multitude of materials-related keywords, such as nanoparticles, silicon, and thin films. The keywords 'performance' and 'model' relate to both system-level and materials research. The researchers publishing the most in this area include Prof. Matti Lehtonen on demand response (143 publications, highest number of publications among Aalto's energy researchers) and Prof. Valeriy Vyatkin (100 publications). The energy materials keyword has been leading the field where individual excellence — such as ERC grants — is measured. Materials research is shown in the top areas (*Figure 18*), not only in 'materials science', but also from an applications point of view in applied physics, physical chemistry, energy and fuels, chemical engineering, and nanoscience. In energy materials research, there is internal multidisciplinary collaboration, which is evidenced in top-ranking publications with contributions from different schools, such as joint publications between SCI and CHEM. When looking at publication volumes on the materials side during the evaluation period, Prof. Esko Kauppinen,

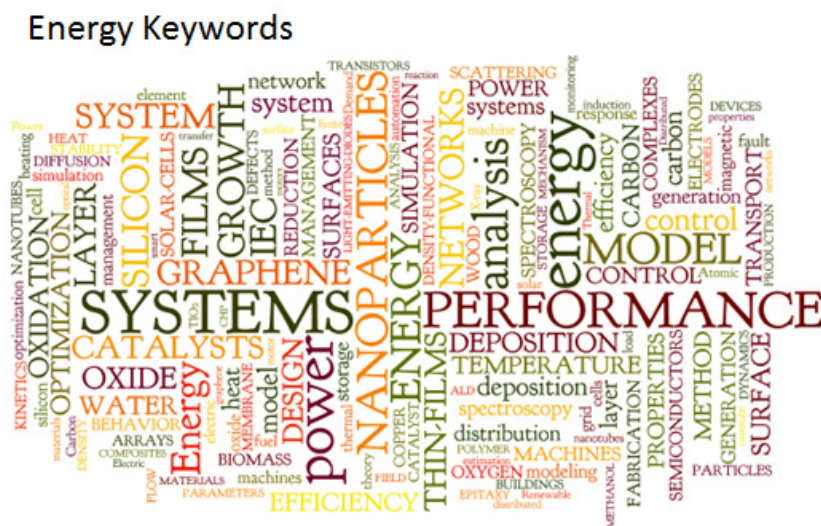


Figure 17: The most common keywords used in the publications by energy professors.

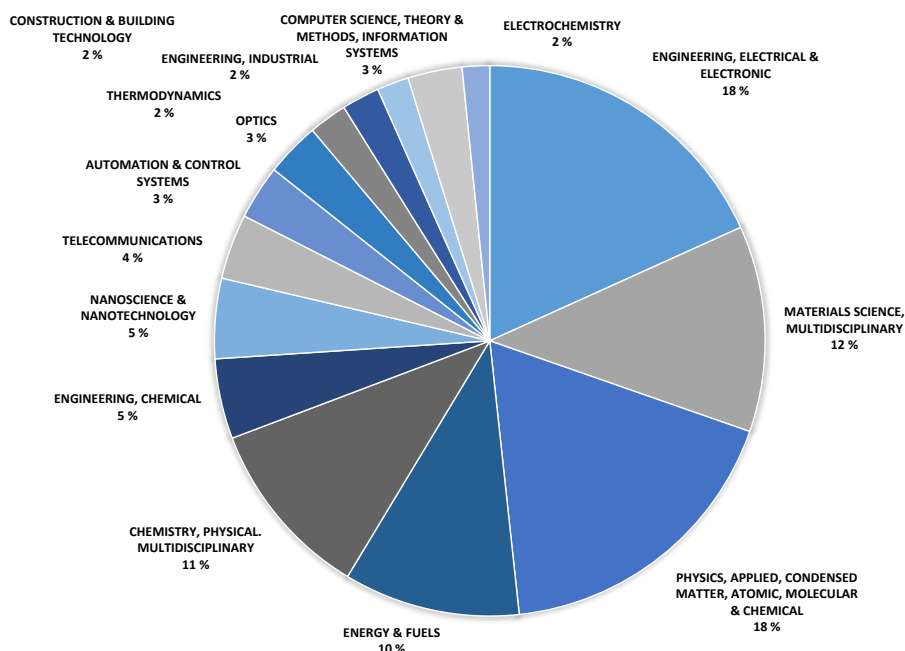


Figure 18: The top research areas in which energy professors publish.

with his work on carbon nanostructures, comes up very high with 80 publications leading to 978 citations (highest level of citations among Aalto's energy researchers). Prof. Maarit Karppinen (inorganic chemistry) and Prof. Harri Lipsanen (nanotechnology) have 70 publications each.

Regarding energy systems and economics keywords, excellence is built even more directly on collaboration: national leadership is evident as Aalto leads three SRC projects and one large strategic opening funded by Business Finland — all multidisciplinary efforts. The energy systems work is largely in the category of electrical and electronic engineering, but also in applied physics, and energy and fuels.

Regarding collaborative research, energy professors from Aalto BIZ and ARTS have an extremely high level of cross-school collaboration (50% joint publications). Both ARTS and BIZ have an enormous 80-81% of publications in collaboration with other Aalto schools. Nineteen percent of publications from both ARTS and BIZ schools contain 3 or more Aalto schools, and in this category, one highlight is that Prof. Sampsa Hyysalo from ARTS has led (first author) three such publications.

In the technical schools (CHEM, ELEC, ENG, SCI), 14-28% of publications are the result of cross-school collaboration. SCI is leading in both absolute (176)

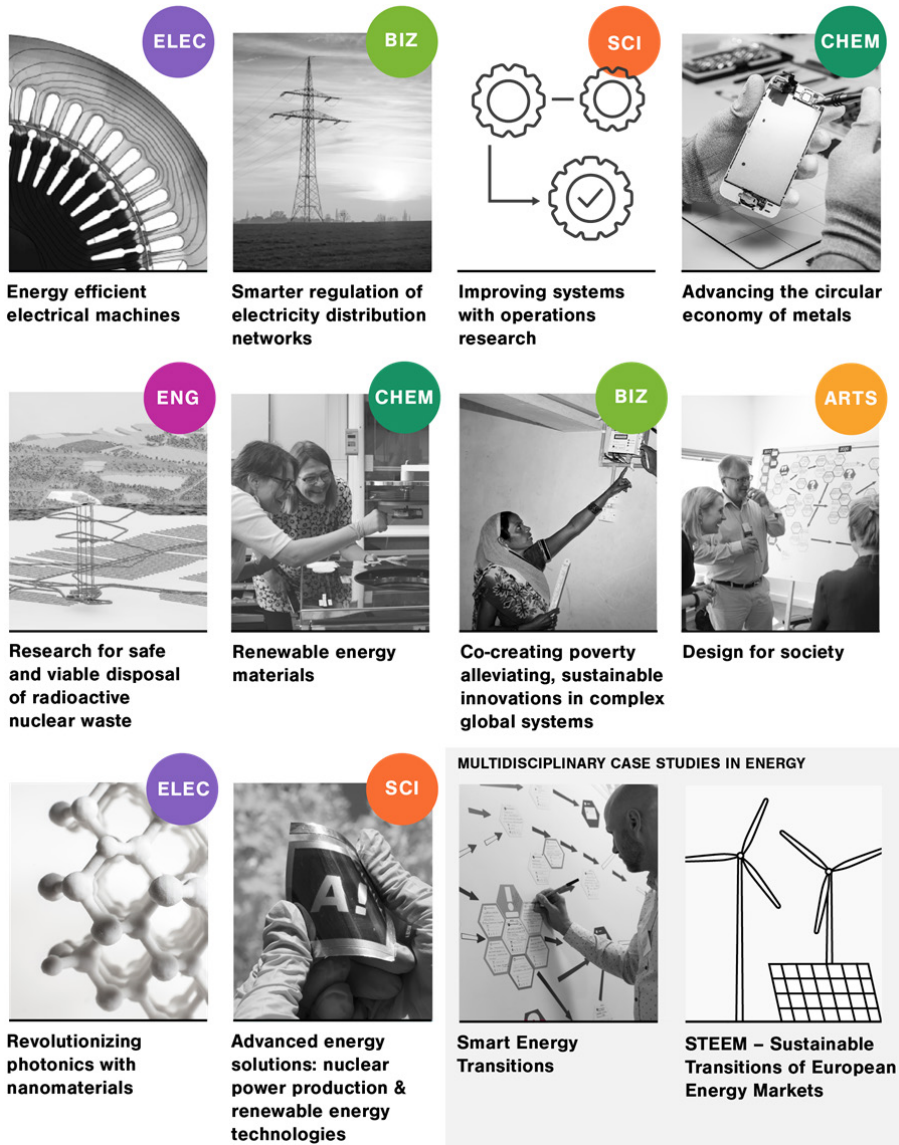


Figure 19: RAI case studies by departments that are directly on energy and those that are highly related to energy. In addition, there are two case studies related to assessment of the energy field that are marked multidisciplinary case studies. Aalto's energy research covers the broad spectrum from molecular level materials design to global energy systems.

and relative (28%) volume of publications with cross-school collaboration. In collaborations among the technical schools, there is a good level between SCI, ELEC, and CHEM. One thing that brings these areas together is facilities, such as OtaNano (<http://otanano.aalto.fi>) at Micronova, where these three schools also meet physically. Typically in these collaborations, one brings expertise from the applications side, one from materials, and one from analysis. There is a healthy level of diversity in the author lists of multi-school collaborative publications, but there are also some professors that show up more frequently. For instance, of 27 collaborative publications that contain 3 or more Aalto schools; Prof. Jari Koskinen (CHEM) has been involved in 12 and Prof. Tomi Laurila (ELEC) in 10 during the evaluation period.

Collaboration was also enforced when energy, as one Aalto focus area, received major investment in the form of the Aalto Energy Efficiency (AEF) programme, which funded nine multidisciplinary consortia (€12m, 2012-2017). All the funded consortia had members from a minimum of 3 schools, and the objective was to tackle bigger questions together than the different disciplines could take on separately. This is one reason that explains the high volume of collaborative publications, but joint work is not only limited to the AEF programme. The purpose of AEF was also to catalyse further collaborative work, and it resulted in several follow-up projects, for example, an ERC project. A €1.8m project, MOPPI (Profs. Kauppinen, Laasonen, Lipsanen, Puska, Tulkki), resulted in 18 spinoff projects — including Aalto-led EU project IRENA (FP7-NMP-2013-EU-Japan/Kauppinen 2013-2017) — with a total of €7m in funding.

Societal Impact, Entrepreneurial and Innovation Capacity

Aalto's energy research is motivated by societal impact. The impact is found both globally and locally. Energy is also an area where societal impact is found across Aalto: every Aalto school presented at least one case study that either was directly on energy or related to energy (*Figure 19*).

Research Environment

The Energy Platform's activities include Energy Breakfast events and other thematic seminars, the Energy Gala, Demo Days, and bilateral company workshops. The events have attracted around 300 participants annually; in 2017, this number rose to over 500. The platform was responsible for the Energy Efficient & Sustainable Campus Competition (2015-2016). The platform has also hosted a number of media events. In 2017, the Energy Platform recruited designers from Aalto ARTS and started giving training and offering opportunities to support the visibility of energy research. The Energy Platform also seeks collaboration with other platforms, for example the Materials Platform and Digi Platform, as well as

with the Aalto Sustainability Hub. Aalto also has strategic partnerships in the field of energy. An example highlight in this area is the Electric Drives Research Group (Prof. Hinkkanen), which develops electric motor drives, motion control, and grid-connected power converters in close collaboration with industry (including ABB Oy and Kone Oyj). The core competencies of Hinkkanen's group are developing model-based, real-time control and estimation algorithms for challenging nonlinear problems. The research funding from companies in Hinkkanen's group alone has been more than €1.8m during 2013-2017. This industrial collaboration has also led to excellent academic results: 20 *IEEE* journal papers in the projects funded by ABB Oy from 2013 to 2017, of which several were externally awarded.

Regarding infrastructure, OtaNano facilities are crucial for new energy materials research in the fields of photovoltaics and carbon nanostructures. OtaNano instrumentation provides world-class characterization tools, including sub Ångström transmission electron microscope (TEM), multiple scanning electron microscopes (SEM), atomic force microscope (AFM), et cetera. The Micronova cleanroom (part of OtaNano) is utilized in various micro- and nano-technology and thin film projects.

Table 9: Significant achievements in the field of energy

SIGNIFICANT ACHIEVEMENTS 2013-2017	Year	Description
Start 3 SRC projects (€13m)	2015-2016	Smart Energy Transitions (Lovio); Winlandia (energy part Syri); ClosedLoop (Karppinen); the first two have strong contribution from energy economics
Start of 4 ERC projects	2012-2016	Prof. Maarit Karppinen (AdG, PoC), Prof. Antero Arkkio (AdG), Prof. Hele Savin (StG)
527 cross-School publications (23.4% of all publications)	2012-2017	Multidisciplinarity is shown strongly in the publications of energy professors.
189 publications IF > 7 journals (8.4% of all publications)	2012-2017	Most of the publications in high IF journals come from the fields of energy materials
Innovation award for Prof. Hele Savin	2015	The award for women (€110k) was given to Prof. Hele Savin by Chancellery Commission of the Parliament for her work with silicon solar cells
Award for Smart Energy Transitions	2017	An award of Aalto excellence funding
Joint Master's programme (Advanced Energy Solutions)	2016	By beginning of 2018, the new Master's programme has courses from all six Aalto Schools

which supports expertise in the design, synthesis, and characterization of a variety of inorganic materials that are needed, for instance, for energy storage and harvesting applications. National Bioeconomy Infra (Academy of Finland-funded infra, FIRI) is an alliance between Aalto University and VTT. Biomaterials infra is relevant for biofuels, and also for investigation of energy-efficient wood.

There are other energy-related collaborative educational programmes at Aalto in addition to the joint Advanced Energy Solutions Master's programme. The Aalto Nuclear Safety programme combines all the nuclear energy-related activities at Aalto University under the leadership of Prof. Filip Tuomisto. The purpose of the programme is to respond to the needs of the Finnish nuclear energy sector, which requires 100-200 new highly educated personnel yearly until the year 2025. Nuclear research efforts are strengthened by collaboration with VTT: the new VTT Centre for Nuclear Safety in Otaniemi, being gradually taken into use, also provides world-class infrastructure for Aalto researchers.

Table 10: SWOT analysis of the research environment

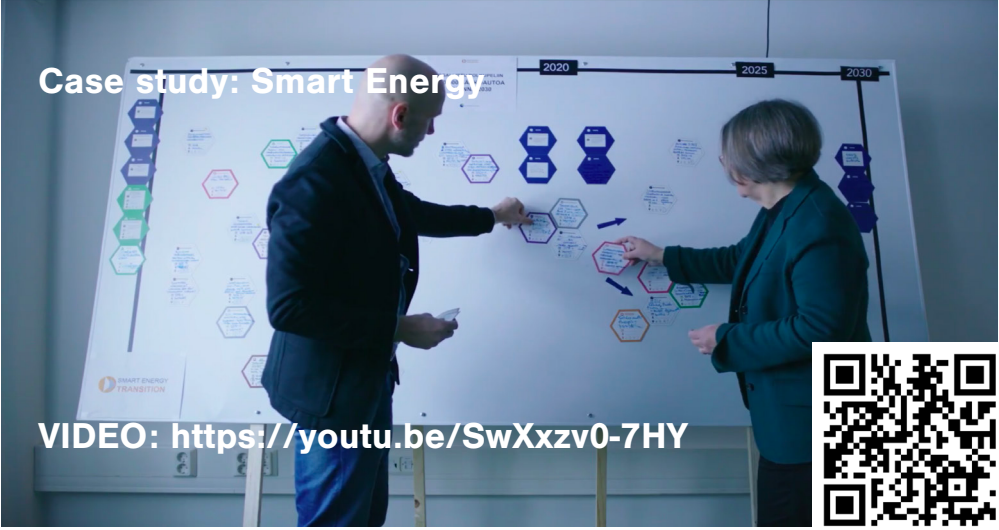
Strengths	Weaknesses
• Breadth and diversity of energy research at Aalto, e.g., materials, systems, business models, consumer side • Capability to frame and address problems • Good contacts with industry • Energetic Aalto community, open to other disciplines • Recently launched joint Master's programme in Advanced Energy Solutions	• Finnish funding system is slow and rigid, makes it slow to do new research • Balance of applied and basic research—because basic research is so far away from application, it is hard to get funded but it is critical for innovations • The interface for negotiating a research project with industry is not optimal as the field is conservative since the investment times are so long
Opportunities	Threats
• Substantial demand, there are lots of pressing issues within the field and public interest is high • Strong supporting fields are present at Aalto, e.g., AI and digitalisation • Energy is interlinked with other key areas, e.g., transport • New developments, e.g., regulation and diversity of energy sources, are shaking things up	• Internal threat is that energy research may be spreading itself too thin and, at the same time, research cannot be too focused since large coverage is needed to educate experts for local industries • Energy is a 'hot field' with many areas—the focus can jump from one thing to another • Investments within energy industries are expensive, so change is slow and difficult

Energy Science Initiative (ESCI), hosted by SCI, focuses on multidisciplinary education and student involvement around timely energy topics. ESCI's Energy Garage facility is aimed at student activities, allowing hands-on work, independent study, and collaboration, as well as workshop facilities. The Doctoral Education Network in Energy Technology (DENET) offers a forum for doctoral students and their supervisors in the field of energy technology. The network is coordinated by Aalto University.

Future Potential

Within general global trends, such as the imminent sustainability crisis, growing population, and geopolitical volatility, it is expected that energy-related research will continue to be increasingly topical. The importance of energy research is further emphasized by quickly transforming energy technologies, which will need their impact assessed and anticipated. Further, such emerging trends as AI and digitalization will provide new opportunities for breakthrough innovations. Aalto's energy research has the potential to solve bigger questions due to the wide base of our research. There are two main broad areas to build future excellence on: 1) energy systems and 2) energy materials. Aalto's energy materials research has already proven excellence, for example, in producing high-impact publications and in obtaining ERC grants. Materials research is carried out widely by CHEM, ELEC, ENG, and SCI. Within the field of materials for energy production, solar energy (ELEC, SCI) is strong at Aalto. As renewable

Case study: Smart Energy



VIDEO: <https://youtu.be/SwXxzv0-7HY>



energy production will grow in the future, energy storage becomes another crucial issue. Aalto's researchers have already come together to tackle this wide issue of energy storage futures, where solutions are sought in electrical storage, other forms of storing energy (heat, fuels) as well as reducing the need for storage (e.g., demand-side management). Energy storage issues also connect both materials and systems-level research.

To reach this high potential in these areas, support is needed in encouraging leadership and bottom-up formation of strategic focus. Furthermore, attraction of international talent and establishing close cooperation with institutions, such as other universities, as well as closer connection to policy making, will be needed.



Case study: Time Travel to Final Disposal

VIDEO: <https://youtu.be/Jqsc-3vZ8wU>



Panel's Field Assessment

Overall Assessment

A good Energy Platform with great campus activities, good impact on society, and good industrial connections. It is currently too much inward-looking and reactive. Given some more time and a clear commitment to a clear strategy and an execution plan, Aalto can make the platform outward-looking and proactive. It has the potential to become a leading energy research hub.

Excellence

Aalto's Energy Platform brings together researchers interested in the field of energy in a broad sense. It provides a cross-disciplinary platform for those working in science, engineering, business, and design. It mainly seems to highlight research in sustainable energy production, energy conversion and storage, as well as looking at the energy efficiency and economics side. It is a large platform involving approximately 70 professors from across the university. Some of these professors are excellent, so overall, the energy research at Aalto seems in good shape. Among these professors are four ERC grants between 2013-2017, and some publications are in journals with an impact factor higher than 15. A strong area seems to be the work in solar energy materials.

There is no doubt that there are several environments that work in energy related research that are excellent. These environments are able to attract prestigious research funding. What is not very evident is to which extent the platform promoted and facilitated excellent multidisciplinary research, although some examples were given (e.g., ERC Proof of Concept grant was inspired by a project from the €12m Energy Efficiency programme, and there is Academy of Finland research funding). It remains a bit unclear whether the platform advances those who are excellent already or that (new) excellence originates collaboration through the platform.

The platform has presented two case studies, which clearly showed the coming together of good research in a multidisciplinary setting. Some 25% of the publications, some with good impact as evidenced by citations, are by authors from different Aalto schools.

Impact

Aalto is perceived as a national leader in energy research. Their success in national funding is high: over 15 million Euros in projects from Business Finland (Tekes) and SRC. The publication output from the platform is excellent; several groups are able to publish in the very best journals, and the impact of the publi-

cations are in many cases excellent. Some energy researchers have reached leadership positions that allow them to influence the future research agenda. Several researchers have received prestigious distinctions. Perhaps there is a bit too much focus on the performance on some excellent individual researchers reaching high impacts and citations.

The case study presented, Sustainable Transitions of European Energy Markets, which refers mainly to the STEEM project, has produced valuable research data which has influenced the academic community through a range of papers published in journals with good reputation.

Societal impact

The societal impact is made very clear, and many aspects are highlighted in the supporting documentation. The platform has a positive effect on the societal impact, in part because it brings together designers, scientists, engineers, and business-oriented scientists. All the different activities that are performed to reach impact in society are impressive. The activity spans broadly. When it comes to future goals, they are not described, nor is it clear how the future agenda is set. For example, a clear reference to the Finnish strategy for energy and climate including nuclear power is missing, however.

There is a good connection between research and applications, and two very important projects here are clearly interdisciplinary.

STEEM: professors have been invited as experts by the Finnish Parliament regarding the legislation initiatives in energy and climate policies. Another good societal output is the comprehensive life cycle study of energy storage systems.

SET: has created national impact on business, design, and the engineering field. They spoke to many audiences, have reached 8 800 listeners as invited speakers and 2 000 listeners as invited experts.

Aalto has clear and long-standing relationships with industry. It is clear that both industry and Aalto benefit from this collaboration. There is no industrial advisory board for the Aalto energy research as a whole.

Finally, the Master's programme that was initiated from the platform is a very good achievement. It fills a clear need in the Finnish academic scene and industry. It is impressive that such programme was realized in such a short period of time.

Research and Artistic Environment

The research facilities for energy research have not been analysed thoroughly by this panel, as this has been done by the departmental panels. The campus-wide efforts to create more shared approaches to using these facilities is good. OtaNano is a good example of such shared world-class equipment, even though it came across more as a collection of facilities than a truly integrated facility.

In this section, we focus on the functioning of the platform. Setting up such a multidisciplinary platform in a new university, under heavy budget constraints, is very tough and requires courage and stamina, which we highly commend.

The setup of the Energy Platform is, given the constraints, deliberately a light organization. This seems appropriate to create a good environment where researchers from different disciplines can feel comfortable when they exchange ideas. The platform provides a forum for discussions, meetings, and symposia, some with large numbers of attendees. The number of such activities is impressive. The platform is thus also a good means for new professors to quickly get to know other professors in energy. The platform's mandate is quite open, and it has chosen to focus mainly internally for this first period. This is reflected in the current strong inward-looking focus of the platform and its (lack of) strategy.

The platform had made an excellent start through the Energy Efficiency Programme of €12m. It fuelled new collaborations, it was run efficiently, and it was well received by the researchers. The projects were rather dispersed in topics, so it was difficult to build upon this initial funding in a strong, coherent way. After this initial research funding ran out, and the Business Finland funding also reduced greatly, the platform has no other financial means to invest in research. They still provide small seed money in supporting new projects, but are not able to develop new directions in energy research. The platform's way of working is bottom-up, and follows ideas and initiatives from the associated professors. It could or maybe should be somewhat more proactive. The platform has no clear communication strategy, and may benefit from being more deliberate in approaching the media and politics, as there is clear evidence that many researchers have excellent personal, albeit somewhat ad-hoc, connections.

Currently, the platform lacks a clear strategy and means to execute this strategy. The platform lacks explicit targets or KPIs, and it was unable to express to the panel when they are considered to be successful by the university management.

Future potential

Energy-related research will be of highest global importance. Based on the high quality of the research, measured by the majority of the publications being in high-ranking journals and a large number of excellence grant, the platform has a strong research potential for the future. It seems that the global impact most likely will be within the focus areas energy systems and energy materials.

While many excellent activities take place, however, it does not seem as if the platform is ready to take the next step and further develop the platform. In particular, more focus is required and a strategic plan on how to take the energy question to the next level. Society develops very quickly, and energy questions are in the forefront of our challenges in reaching a sustainable society. A strategy

should also include how to develop the platform to have an international perspective and to develop industrial interactions.

Recommendations for the multidisciplinary field Energy

The platform clearly is at a crossroads. In past years, the approach has worked, but it bears a great risk that it will slowly die in coming years. Therefore, the platform needs to change its strategy and approach, and it needs to identify its key targets and performance indicators. Either it continues on this foot (not recommended, as we think it will disappear), or it takes the leadership and activities a notch higher to create an even greater and lasting impact on the energy research world. It needs to move from inward-looking and reactive to outward-looking and proactive. More concretely:

Make a strategy and execute it:

- The topics mentioned in Future Potential are certainly relevant but need more specification;
- Develop clear performance indicators, and targets, without them the platform runs the risk of ad-hoc work;
- A strong, visionary leader with serious time and budget to lead this platform;
- Connect to and contribute to national (and international) energy reports and Finnish government plans more explicitly.

The strategy should be supported by university leadership, and this could involve:

- Regular meetings with deans and department heads to create a shared commitment and urgency to invest in this field through, for example coordinated tenure-track positions;
- Additional university funding so that more substantive seed projects can be initiated.

Consider the following means to support the strategy:

- Doctoral education development;
- Install an industrial advisory board – this will also keep the researchers committed;
- Develop a clear communication strategy and associated material (online and offline, for different target groups).



Field: 6
Health and Wellbeing

***Arno Villringer, Chair;** Marta Kwiatkowska; Oliver Brand;
Jan Wikander; Susanne Boll; Thorsten Hennig-Thurau;
Jan Lagerwall; Steve Brown; Daniel Loss; Muffy Calder*

Field Description

The field of Health and Wellbeing (H&W) is one of the seven key research areas at Aalto University. The field comprises six major subfields, as illustrated in *Table 11*.

The H&W field is characterized by significant clusters of high-quality research with high scientific impact and a tradition for innovation. Multidisciplinarity and high-value international collaboration are inherent to the field, and the field is broadly present in Aalto's organization.

Aalto has an opportunity to develop into a very strong cluster and hence contribute synergistically to the joint efforts of Helsinki region organizations to become a top European research and business cluster in H&W. There are inspiring chances to develop the field's academic and societal impact, and the result should be a truly valuable and unique research ecosystem.

The general aim of the H&W field's research community is to create strong academic impact via ambitious, excellent-quality research and artistic activities (and teaching, which is not covered in this evaluation), and to help put our results and expertise into practice. Aalto aims to thereby support economic growth and major positive H&W trends, including individual participation in medical care and upkeep of wellbeing via lifestyle choices; preventive medicine (to avoid costly and widespread chronic diseases); and predictive and personalized medicine via deeper understanding of genomics and other unique human physiological characteristics. Trying to achieve significant cost savings is also an important trend; the potential for such savings via healthcare process redesign is a major opportunity that our expertise supports. Aalto has a strong track record in research, innovation, and architecture in H&W that Aalto can now build on.

Table 11: Health and Wellbeing Subfields and their contents

Medical and well-being devices	• Medical and wellbeing devices and nanotechnologies	Digital health	• Data science and machine learning • Health IT applications
Neuroscience and neurotechnologies	• Neuroscience • Imaging and modulation tech	Management and economics	• Healthcare service and system design, and evaluation on all levels
Biotech, biomaterials, and chemistry	• Synthetic biology, cell-based products, biomaterials, pharma	Architecture and design	• Architecture and building design • Industrial design

Aalto's Health and Wellbeing field has six distinctive subfields

Breadth and multidisciplinary are inherent to the H&W research field, and the field's broad structure at Aalto reflects this. Organizationally, 76 professors at Aalto were active in H&W-oriented work at the end of 2017, including tenure-track, tenured and adjunct professors, and Professors of Practice (Aalto had 388 professors total). While the Department of Neuroscience and Biomedical Engineering (NBE) is near to being solely an H&W department, there are several units with a significant cluster of H&W-focused research groups, for example: Department of Computer Science, Department of Electrical Engineering and Automation, and the School of Chemical Engineering. Nearly all other Aalto units have a presence, at times significant, of H&W-oriented research. While many H&W-active professors work in multiple application domains (not just H&W), Aalto's cluster of H&W research is significant regardless, with much potential for multidisciplinary collaboration in an area of high societal importance.

The following text describes the research subfields where Aalto has internal coherence, a sufficient volume of research, and plans for further development. *Figure 20* illustrates the foci, presenting a cloud of keywords in the field's publications.

Medical and wellbeing devices (Chair: Prof. L. Parkkonen). We develop electrical and mechanical technologies with a broad scope in the H&W area, targeting solutions deployable in large volumes to individuals as well as highly specialized methods for healthcare professionals. Much of our work is deeply intertwined with the neuroscience and neurotechnology subfield (and many researchers work in both). This work focuses on approaches for non-invasive stimulation and imaging of brain structure and function; we develop, for example, hybrid imaging (combination of magnetoencephalography or MEG and ultra-low-field magnetic-resonance imaging or MRI in the same system), high-resolution MEG with on-scalp sensors, multi-locus transcranial magnetic stimulation (TMS) with electronic control of the stimulation target area, high-precision modelling of transcranial electric stimulation (TES), and other neurological rehabilitation.

Neuroscience and neurotechnologies (Chair: Prof. R. Ilmoniemi). We study the human nervous system with pioneering technology that enables advanced measurement, analysis, modelling, and modulation of the system. Aalto has a strong, decades-long history of collaboration among neuroscientists, physicists, computer scientists, engineers, and medical professionals. Our technologies and innovations in instrumentation as well as our methods are motivated by the needs of scientists and clinicians and open, in turn, unexpected new possibilities for research. We track neural processing in healthy human brains to uncover the

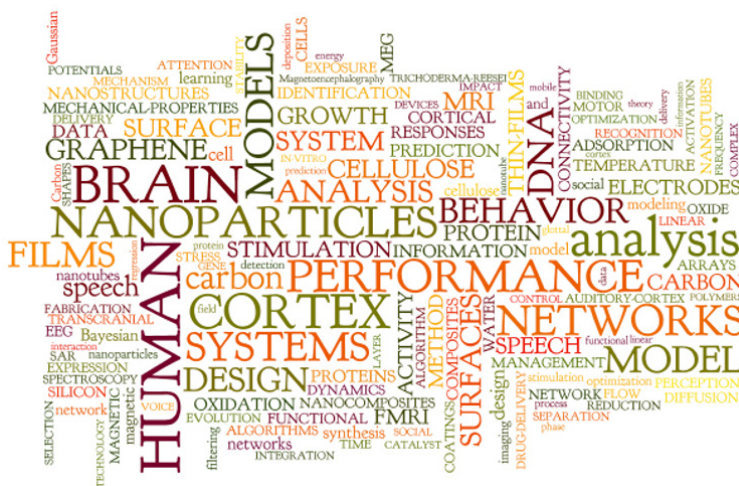


Figure 20: A visualisation of the prominence of keywords in the publications of H&W's professors.

neural mechanisms of the human mind and behaviour. Aalto has a rich mix of non-invasive imaging methods under development at Aalto: MEG, its combination with magnetic-resonance imaging (MEG-MRI), near-infrared spectroscopy (NIRS), and dual-MEG. We also use functional MRI, electroencephalography (EEG), and behavioural measurements for our research. Aalto is also active in innovative and important intervention technologies, such as navigated transcranial magnetic stimulation (nTMS) and TES. All these are under our research and development, and most are already established or target clinical applications.

Biotechnology, biomaterials, and chemistry in H&W (Chair: Prof. J. Seppälä). Biotechnology and bioengineering are developing at an exceedingly fast rate to offer novel solutions, technologies, and products for fulfilling the fast-evolving needs of the H&W sector. Aalto's profile in this area is multidisciplinary and scientifically competitive, both at the level of basic research as well as that of the development of new medical applications.

We are active in the study of application opportunities that target personalized medicine, synthetic biology, regenerative medicine, rapid diagnostics, and production for unit operations for the biorefining of highly specialized value-added compounds from bio-based raw materials. Underlying technologies include nanotechnologies, biopolymers, microfluidics, microarrays, high-throughput screening, and bioprocessing.

Industrial biotechnology includes the disciplines of biochemistry, microbiology, biomolecular materials, and bioprocess engineering. High-level skills in organic chemistry synthesis and analysis in combination with chemical

engineering are in a crucial role in developing modern active pharmaceutical agents, biomaterials, diagnostic technologies, and their production technologies. Synthesis and tailoring of novel biomaterials includes polymeric biomaterials, bioactive materials, and biomolecular materials as well as inorganic biomaterials.

Digital health (Chair: Prof. J. Rousu). In digital health, our expertise is founded most particularly on world-class research in machine learning and data science. This creates paths toward significant health applications, such as in drug sensitivity prediction, personalized cancer medicine, and the analysis of epidemics, along with technological solutions for outpatient care. Further, related to Aalto's neuroscience subfield, Aalto has studied natural brain-information interfaces, for example. Our research distinguishes itself internationally by the strong focus on developing machine-learning and data-analytical methods for high-throughput genomic and molecular data, which are key building blocks of personalized medicine and drug discovery. We develop these applications in tight collaboration with top-class medical experts nationally and internationally.

The management and economics of H&W services (Chair: Prof. P. Lillrank). In this subfield, we are significantly active in healthcare operations management (HOM) and related policy research. The objectives are to understand health services as socio-techno-economic systems of processes, to develop and validate new methods for management, and to inform policy. We approach these topics from the paradigmatic approaches of management studies and systems-analytical research.

We are significantly active in this research on all levels, from the patient-process level via the department, hospital, and regional levels to the level of national healthcare systems and policy. We work closely with health service providers, both public and private, and develop insights and tools for process analysis and regional service system design.

Architecture and design in the H&W sector (Chair: Prof. P. Sanaksenaho). The research concerning architecture and design in the field of H&W is one of the core areas at the Department of Architecture and at the Department of Design. The Sotera research unit at the Department of Architecture concentrates on the social and health care sector: on the design and development of buildings and service structures as well as related technology. Our multidisciplinary research teams employ, but architects and designers, also economists, statisticians, computer scientists, futurologists, and civil engineers. Our research focuses on the user experience and value creation in the processes of healthcare. User-driven research related to the accessibility of apartments and their immediate surroundings as

well as access to services are our key areas of expertise. The methodologies of practice-based research are in use.

On the H&W field's role and international benchmarks

H&W enables a key opportunity for Aalto to make academic and societal impact. H&W is a societal Grand Challenge where Aalto can help tackle very significant problems based on highly multidisciplinary, top-tier research in an area of strength at Aalto.

The technologies possible in H&W are a potent growth vehicle for economies. Looking at Finland, health technology—a paramount H&W cluster at Aalto—has been among the two most significant national high-technology export sectors in recent years. It builds on a substantial cluster of large- and middle-sized companies, in which the Helsinki region is very strong. Exports have been growing extremely fast compared with the overall economic situation (e.g., 2008-2012: up an average 8.1% per year, despite economic downturn; 2013: 1.0%; 2014: 8.3%; 2015: 6.6%; 2016: 9.7%; figures from the trade association Healthtech Finland). About 95% of Finland-manufactured health technology is exported, which says something about the sizable economic significance of this all for a country of 5.5 million people.

The most significant international role models and benchmarks of Aalto's H&W field are the research ecosystems of Harvard University, Massachusetts Institute of Technology, and their vicinity in Massachusetts (USA), which includes several leading university hospitals; the European Molecular Biology Laboratory and the Sanger Institute in Cambridge (UK); and ETH Zurich's Basel campus (e.g., machine learning). Nordic ecosystems, such as the Danish-Swedish Medicon Valley (in Zealand and Skåne), Stockholm with the Karolinska Institute, and Gothenburg with Chalmers University of Technology, are further benchmarks.

Excellence, Quality, and Multidisciplinary Collaboration of Research

Aalto's H&W field has a generally high level of ambition and often very good academic quality, with a number of research groups reaching true excellence (*Table 12*). We point out that the bibliometric figures used to describe the H&W field in this report include all publications of Aalto's professors who have H&W-related activity. This outcome, partly a technical necessity, usefully shows the width of expertise that their often disciplinary research may contribute.

As mentioned, Aalto's work in H&W is multidisciplinary. Much of this is due to the work's very nature, for example, neuroscience and biomedical data science are by definition—and in practice—multidisciplinary. Nearly all of our medical device researchers, and many digital health, biotechnology, and chemical researchers,

work with clinicians to develop and study technologies.

At Aalto, our field is horizontally very wide: there is a significant number of H&W-active professors at all schools (ARTS: 10; BIZ: 8; CHEM: 13; ELEC: 7; ENG: 8; SCI: 30), and expertise. A significant percentage (30% to 80%) of publications have a co-author from another Aalto school. However, the collaboration is very much centered around the School of Science. *Figure 21* outlines the distribution of the Aalto H&W professors' research into various areas. This shows very high potential for multidisciplinary.

Table 12: Scientific impact and innovations

Reported merit	2013	2014	2015	2016	2017	Total
Academician*	1	1	1	1	1	
Academy Professor	5	5	5	5	2	
Centre of Excellence, Coordinator** or Partner	3	3	3	3	3	
Publications in high-impact factor journals (IF > 7)	14	16	21	17	21	89
Publications with 2 schools collaborating	35	44	48	42	47	216
Publications with ≥ 3 schools collaborating	0	3	7	10	1	21
All publications by H&W researchers	252	294	294	280	207	1 327
Invention disclosures: trend from NBE***	1	5	9	13	8	36

* A national title of the highest prestige, held by max. 16 Finns at a time (except artists).

** Coordinator in COIN and HYBER.

*** The figures are from a leading H&W department: Neuroscience and Biomedical Engineering.

Furthermore, two ERC Advanced grants, several non-Advanced ERC grants, and 3 Future and Emerging Technologies (FET) projects address H&W.

Impact of the Research Activities on the Research Community

Aalto's H&W professors publish a notable amount of papers each year, and their aggregate output includes 1 327 publications from the period of assessment. They have been cited 9 589 times with a 7.33 citation impact. International collaboration is present in about 52% of the publications of Aalto's H&W professors, although this likely varies by subfield. In neuroscience and related medical devices during 2013–2017, the merits include three Academy Professorships, a large number of other Academy of Finland-funded projects (2013: 42; 2014: 35; 2015: 33; 2016: 34; 2017: 30), one ERC Advanced grant, two ERC Starting grants, three EU Future and Emerging Technologies (FET) grants (one coordinated), a membership in the FET Advisory Group, and many invention disclosures (36), several leading to patent applications.

Societal Impact, Entrepreneurial and Innovation Capacity

Much of Aalto's technological research builds on a strong and broad culture of innovation from decades-long activity as the Helsinki University of Technology, one of Aalto's predecessors. Basic and applied research often happen in close collaboration. Many research projects are routinely conducted in collaboration with companies and hospitals, often partially with their funding. Our research has led to technological innovations with significant potential for improving the accuracy or timeliness of medical diagnoses and important aspects of medical treatments, such as effectiveness, quality, and safety. See examples in *Table 5*. We estimate that Aalto has produced a relatively impressive number of invention disclosures in the assessment period⁸. Many professors are, moreover, advisors for companies.

Aalto has been pivotal introducing professional management thinking to the Finnish healthcare sector. Our research from the viewpoint of professional

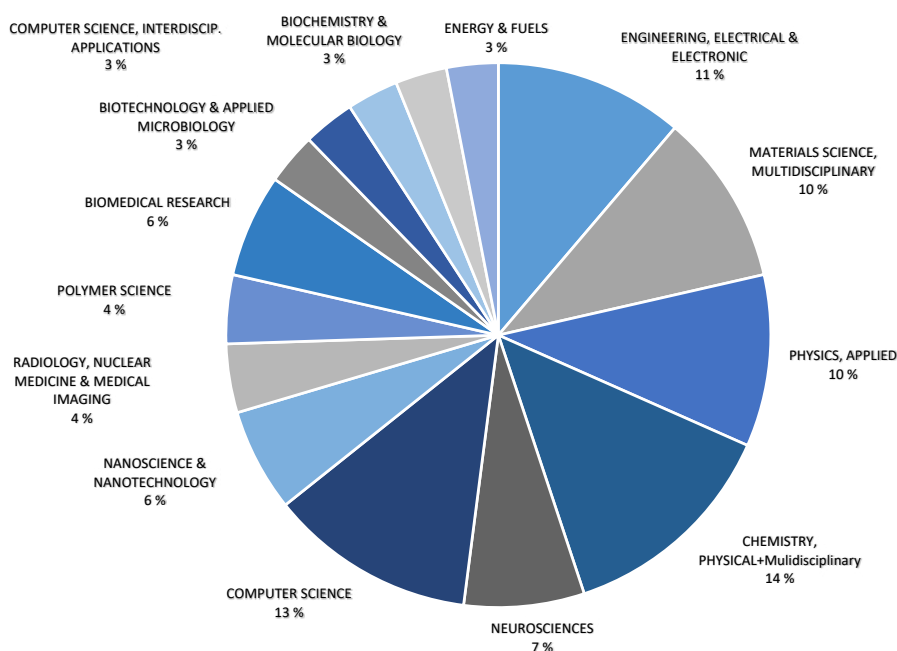


Fig 21: The top disciplinary and topical areas represented in the work of Aalto's H&W professors.

⁸ For example, there were 36 invention disclosures just from the department (NBE) with the largest density of H&W research. As for generalizing this observation across Aalto, we regret that technical and policy reasons do not permit an Aalto-wide count, due to difficulty of accurately ascribing inventions as H&W ones. Though NBE has a higher density of H&W research than others, we believe the rising trend can be generalized.

engineering of service processes (operations management), has led to significant and commercialized knowledge about how to organize processes and systems to provide social, health, and elderly care services. These topics are studied with leading Finnish healthcare providers, and new knowledge is distributed via consultancy work, for example. Such knowledge may generally have extremely significant cost-savings benefits for society, as well as lead time and quality benefits, and even benefits for treatment efficacy and safety.

Table 13: H&W spinoff companies and selected architectural contributions

Company	Solution	Company	Solution
ELSI Technologies	Intelligent floor to prevent falls of the elderly	Synoste	Bone-lengthening solution for skeletal disorders
Etsimo Healthcare	Machine learning for various healthcare applications	Apple Beddit*	Light monitoring system for sleep quality; Apple acquired Beddit and markets products
MEGIN	MEG technologies for research, diagnoses, and treatment planning	Klinik Healthcare Solutions*	Telehealth for patients and care evaluation tools for professionals
Nexstim	TMS technologies	Photono*	Ophthalmological devices
Nordic Healthcare Group	Consultancy for designing healthcare provision processes and organizations	SWAN Cytologies*	Enhanced cytologies (based in Toronto, Canada)
Sense4Health	Sensor and data analysis solutions	New national Children's Hospital**, Helsinki	A nationally very prominent major hospital project
Sooma*	Transcranial electric stimulation	Espoo's Jorvi Hospital**	A major new hospital building for Finland's 2nd-largest city
Surgify Medical	Bone cutting tool for brain surgery, supported by an absolute world-star neurosurgeon (Prof. Juha Hernesniemi)	Jyväskylä's Hospital Nova**	A new 100 000 m2 GFA, €411m hospital building for the Central Hospital of the Central Finland province

* Spun off significantly or fully from an Aalto professor's research or expertise before the professor worked at Aalto; or the company markets a derivative product of the one spun off.

** Architectural design and in some cases also broader management of building design.

Some companies were spun off earlier than the evaluation period but significantly contributed during the period (MEGIN, Nexstim, Nordic Healthcare Group) or listed due to their prominence (Beddit).

Research Environment

Aalto has directed special attention to facilitating collaboration. For this purpose, in 2016 the university created the Aalto Health Platform. This organization helps professors and research groups expand their collaborative work within the university and with the university's external partners, such as universities, hospitals, other research institutions, companies, governmental administration, relevant associations, and the media. The Health Platform brings people together, encourages research and other collaboration, and coordinates the development of research, artistic, and impact activities in H&W across the university and with our partner organizations. The platform aims to support the societal impact of Aalto's work through many outreach activities and acts as a single point of contact for external stakeholders.

The Health Capital Helsinki alliance (HCH) is an important collaboration for Aalto, bringing it closer to important partners, and facilitating innovation and joint company collaboration.

The Aalto Brain Centre synergistically unites Aalto's brain researchers, supports basic research, and disseminates its results for the lay audience. The Sotera Institute broadly brings together experts in built environments from Aalto and external organizations to develop designs for healthcare facilities. Aalto University's Otaniemi campus provides ample co-working spaces for researchers in various fields, startup companies, and established companies.

Significant infrastructures. There are various high-quality infrastructures that Aalto leverages for its research in H&W, which are often included in the Finnish National Roadmap for infrastructures. The NeuroImaging infrastructure comprises state-of-the-art imaging and neurostimulation technologies. NeuroImaging is hosted partly in Otaniemi and partly in the BioMag Laboratory on the Meilahti medical campus. BioMag is co-owned and co-developed by Aalto, Helsinki University Hospital, and the University of Helsinki.

The BioEconomy infrastructure consists of operations from fractionation and separations to chemical and biochemical conversions including synthetic biology. This largely open-access infrastructure enables refining of biomass to high value chemicals, bio-materials, and energy, and is an alliance between Aalto and VTT.

The OtaNano infrastructure comprises two H&W-related infrastructures: the Micronova clean space (Aalto's part is called Nanofab) and the Nanomicroscopy Center. OtaNano is the national research and development centre for micro- and nanotechnology, and it serves as a state-of-the-art working environment for quantum technology, nanoelectronics, micro- and nanophotonics, and new materials. OtaNano provides state-of-the-art capabilities in fabrication, structural characterization, and measurements of nanometer-scale structures and devices

in a unique environment for this research in Finland. For H&W research, OtaNano supports studying and developing applications for medical imaging, monitoring, diagnostics and drug development.

Science-IT is a computational infrastructure for demanding research. Its resources include, among others, Aalto's high performance computing cluster Triton. Via the Finnish Grid and Cloud Infrastructure, Finnish universities including Aalto may share computational resources. Aalto's H&W researchers also use the Finnish national center for supercomputing, CSC. It provides high-power and high-quality ICT expert services for research and other uses.

Overall environment. Aalto has a very good environment, yet with significant development potential – specifically in that the strong multidisciplinary strengths that HCH can bring still remain partially unleashed; Aalto's H&W community could be larger in several of our thematic subfields; and investment into infrastructures would support the rise of our impact. Internationally, we believe Aalto has an opportunity to develop significantly, such as toward a European top-5 city position in research in selected health technologies in particular. In electromagnetic neuroimaging and neurostimulation, Aalto has a chance at becoming the world leader.

Future Potential

Aalto H&W's vision is to be the top Nordic and among the top 10 European universities in its subfields of health and wellbeing in 2030, including societal impact. Although the difficulty achieving this much depends on the specific discipline where H&W research is being done, the objective is suitable.

As for research infrastructures, in devices research, Aalto would benefit from yet better prototyping and testing environments, and from collaboration with the Finnish Centre for Artificial Intelligence that Aalto has recently established with the University of Helsinki.

Panel's Field Assessment

Excellence. Health and wellbeing is an important and highly competitive topic worldwide, and work at Aalto on medical devices and imaging, biomaterials, and digital health builds on some of Aalto's unique strengths. The six subfields cover areas of which some are of top relevance for the health system of the future. In these subfields, there are many interesting - but still fragmented - activities. While there are clear pockets of excellence, no overarching synergistic strategies can be identified yet. Given the only recent creation of the Aalto Health Platform, the panel thought it to be premature to judge synergistic effects and excellence of the overall field at this point.

Impact. The impact of this field still reflects mainly the impact of the many participating departments and professors which are – of course – still quite heterogeneous.

Societal impact. While there are some very promising activities, including Biodesign Finland and Health Capital Helsinki, the panel was missing a clear overall enabling structure, personal identification with the field, and strategic initiatives. There are several very good examples for societal impact based on the participating researchers and their departments. However, these examples come from so many different areas that it is difficult to identify something like a 'corporate identity' of the overall health and wellbeing field. The panel missed overarching goals to meet major current challenges in the field of health and wellbeing (typically expressed by players and stakeholders in health care).

Research Environment. The newly formed Aalto Health Platform is a very promising structure; in the future, it will be very interesting to measure its achievements against its stated goals of internal and external matchmaking and research coordination. The fact that there is very little funding for this crucial component of the field seems problematic. Generally, for this field to be a 'key research area of Aalto University' significantly more funding for strategically structuring it is needed.

Given that patients, customers, and competitors in the global field of H&W are primarily outside Finland (as highlighted in the report), the lack of non-Finnish researchers in the key H&W leadership team presented to the panel is not encouraging. Likewise, gender balance needs to be improved, in particular considering that H&W addresses female as well as male patients and customers, in some cases even only females. The response that 'we have not been lucky' when this issue was

raised was not convincing. The H&W management needs to be more proactive in recruiting excellent female, as well as non-Finnish, researchers with leadership roles.

Future potential. This is an area with very high potential for research output, and medical and societal impact. Given the many involved excellent researchers and departments, Aalto's chances are very good to become a major player. However, the definition of overall strategic goals, efforts to effectively bundle activities, and focus on certain areas are crucial for future success.

Recommendations for the multidisciplinary field Health and Wellbeing.

The field needs clearer definitions of synergistic research goals that may guide seeding opportunities, hiring recommendations, and/or acquisition of equipment.

As enabling mechanisms one may consider:

- (More) seed funding for joint projects of Aalto with HUH or within Aalto;
- Joint acquisition of equipment with HUH;
- Joint professorships (or perhaps even joint research units) of Aalto with the University hospital and/or University of Helsinki;
- Joint doctoral programs (e.g., a joint MD/PhD program) between Aalto and HUH.

Adequate funding and management structures are necessary for these mechanisms and to meet the overall goals of the Health Platform. We recommend proactive mechanisms to achieve gender balance.



Field: 7
Living Environments

***Peggy Deamer, Chair; Rachelle Alterman; Kees Dorst;
Maria Sabrina Greco; Thushara Abhayapala; Andrew Odlyzko;
Daniel Loucks; Ragnar Larsson; Susan Kozel***

Field Description

Living Environments is one of the seven key research areas of Aalto University. The area is wide since many fields of research have an impact on our living environments. It is divided into four main sub-areas and grows organically: through the formation of research networks on topics that have research teams working in multiple disciplines across different Aalto schools. Architecture, city planning, and civil engineering have already been taught for more than 140 years (including the previous Helsinki University of Technology and Aalto University). Finnish architecture and design have a good reputation based on the high level of education and its connection to practice.

The four sub-areas are urban life, human-centered design and planning, inclusive environments, and technological breakthroughs. These areas include research on housing, mobility, water and landscape, perceptual and experienced environments, art and cultural heritage, learning environments, environments for health and wellbeing, human-centered design, urban planning dynamics, wood for living environments, sustainable materials, and building design/architecture, construction, and management.

Aalto University and the University of Helsinki have started a collaboration called the Urban Academy, the aim of which is to integrate research and education from different disciplines into the two universities to address pressing topics concerning cities, urban development, and urban living.

Table 14: Statistics

Reported merit	2013	2014	2015	2016	2017	Total
Architecture competition 1st prizes	5	6	5	4	4	24
Planner training (YTK long course)	33	38	41	42	50	204
School	ARTS	BIZ	CHEM	ELEC	ENG	SCI
Professors working in the Living area	23	11	4	6	29	13

Subfields (focus areas) and their contents			
Human-centered design and planning	• Service and user-centered design, participatory planning, architecture	Inclusive environments	• Learning environments • Living environments for children and elderly people
Urban life	• water, climate change, mobility, housing, and cultural heritage	Technological breakthroughs	• Sustainable materials, arctic and marine environments

Research Profile. The scientific research and artistic projects dealing with human-centered living environments at Aalto benefit from the unique combination of technology, art, design, architecture, and economics at the university.

The general aim of the living environments area is to create academic and societal impact through research and artistic activities, teaching, and collaboration with governmental and city organizations, companies, and third and fourth sector organizations, and hence bridging the gap between research and practice. The results are taken into practice through multiple means, such as case studies, proof-of-concept projects, and competitions, conducted with these organizations.

Aalto University created the Living+ Platform in 2016 to foster and facilitate collaboration in the human-centered living environments area. The four major subareas, listed above, were identified in a strategy process with the platform board. These subareas are focal areas, and as such, are quite wide in their scope. Their purpose is to enable the creation of more topical research networks when and where needed.

The platform helps professors broaden and deepen their collaboration networks, both within Aalto University and with external partners, such as companies, other research institutions, cities, regional governments and other governing bodies, governmental administration, relevant associations and influence groups, and the media.

The area of living environments covers all schools of Aalto, especially the School of Arts, Design and Architecture (ARTS) and the School of Engineering (ENG) and its Department of Built Environment. Studies on materials, the circular economy, urban economy, digitalization, and lighting and sound are also research areas pursued by the unit in other schools (Schools of Chemical Engineering or CHEM, of Business or BIZ, of Science or SCI, and Electrical Engineering or ELEC). The multidisciplinary collaboration in the field is quite unique among international universities. The Living+ Platform has been created at Aalto to foster this collaboration through seed funding for multidisciplinary research applications and events to facilitate contacts between diverse researchers.

Excellence, Quality, and Multidisciplinary Collaboration of Research

The human-centered living environments research area is interdisciplinary by nature. The four main areas of research represent themes that have one or more multidisciplinary research networks inside the university.

This work extends to scientific research and the production of architectural and design works. The results are disseminated in a wide variety of forums—from scientific and professional journals and books, to exhibitions and architectural co-productions. The interdisciplinarity of the area is evident in that almost one-third of the publications have authors from two or more schools. However, many of the works created in some of the major areas in living environments are not catalogued in the Web of Science, from which these figures have been created, and hence the figures provide only a partial view of publications in the whole living environments area at Aalto.

In the area of human-centered design and planning, Aalto has been ranked 9th in the QS World University Ranking for Arts and Design and in place 46 in architecture/built environment. Human-centered design and planning deals with questions of participatory planning and has resulted in internationally recognized research in, and work on, how to develop participatory processes and methods for participation (see Case Study on participatory planning and design processes).

In the urban life area, Aalto hosts an active multidisciplinary network of researchers working on mobility, combining transportation engineering, urban planning, business digitalisation, organization theory, and design, among others (see case study on understanding and supporting disruption and technological transition in urban mobility).

Table 15: Co-authored publications between schools in the living environments area

Publications of the School	Number co-authored with						Single school publications	Share (%) co-authored with					Single school publications	TOTAL %*
	ARTS	BIZ	CHEM	ELEC	ENG	SCI		BIZ	CHEM	ELEC	ENG	SCI		
Arts, Design and Architecture (ARTS)	51	10	6	0	8	9	23	19.61	11.76	0.00	15.69	17.65	45.10	100.00
Business (BIZ)		94	0	2	6	19	61		0.00	2.13	6.38	20.21	64.89	100.00
Chemical Engineering (CHEM)			177	2	8	31	132	0.00		1.13	4.52	17.51	74.58	100.00
Electrical Engineering (ELEC)				388	35	36	315	0.52	0.52		9.02	9.28	81.19	100.00
Engineering (ENG)					550	31	467	1.09	1.45	6.36		5.64	84.91	100.00
Science (SCI)						400	281	4.75	7.75	9.00	7.75		70.25	100.00

Left, the total number of publications (orange highlighting), the number of publications co-authored with other schools, and those published by single school only. Note: The numbers may not sum to total number of publications because some publications are collaborations between 3 or more schools. Right, the data as percentages, e.g., row BIZ column ARTS shows that 10.64% of all BIZ publications were co-authored with ARTS.

Table 16: Impact of the significant achievements of faculty and students in the field of Living environments

SIGNIFICANT ACHIEVEMENTS 2013-2017	Year	Description	Outreach/Other information
Mobility as a Service (MaaS) concept	2014-	Conceptual work for mobility as a service	This work started the global MaaS phenomena that has created publicity, changes in legislation, and numerous companies
Urban Solutions Group	2017-	Joint multidisciplinary research collaboration network with University of Helsinki and cities; a joint Master's programme with the University of Helsinki	Aalto Living+ hub to be started 2018
Spatial planning & transportation engineering Master's programme	2016-	Master's programme joining spatial planning and transportation engineering	The programme brings together students of urban planning and transportation ending the lifelong silos between professions
Energy Efficient townhouse	2013-2017	Carbon efficient townhouse concept suitable in Finnish context	Multidisciplinary research project part of Aalto Energy Efficiency Research program, AEF
Wood programme	2013-2017	IAP non-degree programme	Programme directed at international students of architecture, artistic recognitions

Impact of the Research and Artistic Activities on the Research / Artistic Community

Regarding excellence in the area of human-centered living environments, we can look at publications with high impact and artistic competitions, for example in architecture, in which Aalto teams have been successful.

The keywords cloud in *Figure 22* shows the strengths of Aalto in providing a systems view of our living environments, human-centered understanding, and use of sustainable materials, such as wood. The systems view pervades the university: from design to urban planning and the rising mobility area, to automation systems, digitalization, and to understanding the effects cities have on our climate. Aalto is part of the Finnish Centre of Excellence for Laser Scanning Research through Hannu Hyyppä.

Aalto also participates in university networks in living environment areas. Both faculty members and students have excelled in national and international architectural competitions, winning 19 and 6 first prizes, respectively, during 2013-2017, and they have been introduced in international exhibitions, including

the main exhibition of the Venice Architecture Biennale 2016 (Hollmén, Reuter, Sandman), the World Schools of Architecture series at the Takenaka A4 Gallery in Tokyo (Wood programme), *Echoes – 100 years of Finnish architecture and design* exhibition (Prof. Pirjo Sanaksenaho), as well as in some of the best architectural magazines and several books. The Public Library and Socio-Cultural Center of Aduanas del Mar in Xàbia, Alicante, Spain, designed by Aalto researcher Fernando Nieto, was shortlisted for the Building of the Year 2018 Awards in the architectural platform *ArchDaily*, category Cultural Architecture 2017, as one of the 12 most popular Spanish built works in 2017 in the architectural platform *Plataforma Arquitectura*, and one of the 12 inspiring projects celebrating Spanish culture in 2017 for the architectural platform *Architizer*.



Figure 22: Word cloud of the keywords used in publications in the Aalto Living environments area.

Societal Impact, Entrepreneurial and innovation capacity

Our research groups and networks work closely with public administration and private companies, providing the newest understanding of research findings for both public and private use—very often with innovation funding from the national technology agency Tekes (now Business Finland). These projects have some funding from Tekes, they require industrial partners, and typically include co-funding from participating companies. The research groups in the Aalto living environments area have worked with many Tekes projects, such as the *Energizing*

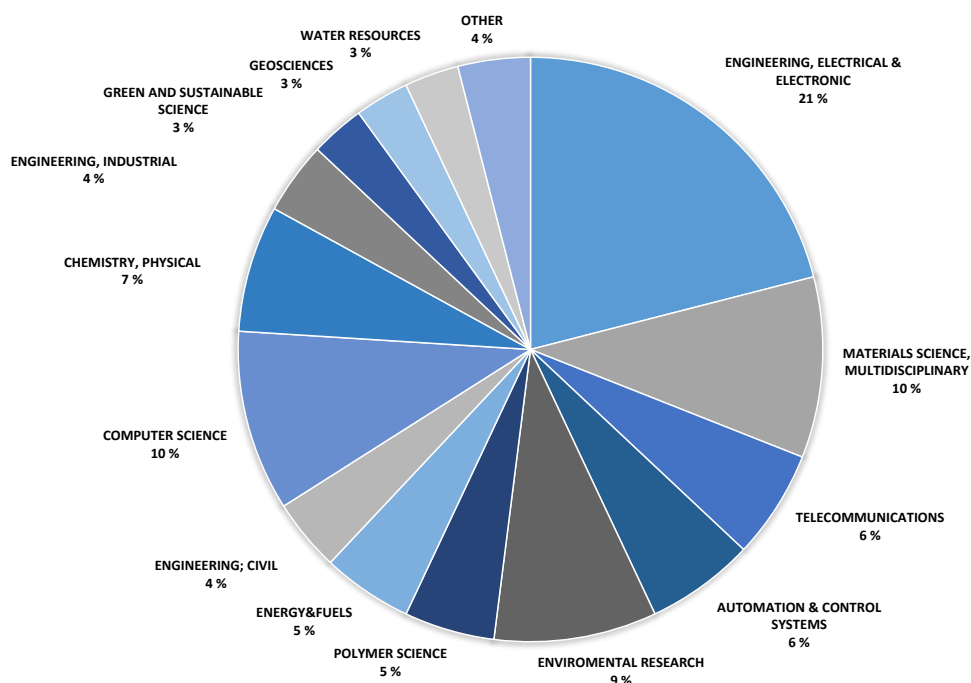


Figure 23: The top disciplinary and topical areas represented in the work of Aalto's Living area professors, consisting of 1 557 publications. Data extracted from Web of Science/ InCites database produced by Clarivate Analytics and based on publications from years 2013-November 2017. Document types included: Peer-reviewed Articles, Reviews, and Proceedings Papers.)

Urban Ecosystems Tekes/SHOK project (coordinated by Aalto), which helped spread a 'quadruple helix' within the Finnish construction ecosystem.

Aalto's research in human-centered living environments is tightly interwoven with societal impact. The research groups have long-standing collaboration with cities, government agencies, industry, and third and fourth sector organizations, forming a quadruple helix. We work with dozens of cities, with all major construction companies (e.g., Skanska, Bonava, YIT), and all major consulting companies (Ramboll, SITO, FCG, WSP, Pöyry, Sweco) in Finland.

In the human-centered area, we have built extensive collaboration with cities in many areas of living environments, including participatory planning and design, architecture, water engineering and landscape architecture, and mobility.

For example, water engineering and landscape architecture groups have been collaborating with cities to provide new ways to allow simultaneous handling of storm water and improving our urban environments by utilizing stormwater as a spatial element in urban environments.

Aalto also leads two Academy of Finland Strategic Research Council projects in the living environments: *BEMINE*, which works on city systems level understanding of urban planning, and *From Failand to Winland*, which explores future energy and food security in Finland.

Aalto researchers have developed soft-geographic information system (GIS) methodology to collect location-based information from participants. This soft-GIS methodology has been spun off as a company, Mapita Ltd., which provides the Maptionnaire tool for global use. Maptionnaire has been used in over 2 000 projects in more than 80 countries, both in research projects and in participatory planning practice-oriented projects. These surveys have reached over 400 000 participants, who have made over 800 000 place markings. The users of the service include the City of New York and Denver in the USA, Stockholm (Sweden), Helsinki, Espoo and Vantaa (Finland) and the universities of Wisconsin-Milwaukee (USA), Auckland (New Zealand), and Copenhagen (Denmark).

Our professors are members of the boards of relevant professional associations. Some examples of these include the Finnish Society of Indoor Air Quality and Climate (FISIAQ), the Building Information Foundation, the International Sustainable Campus Network (International Universities), the Museum of Finnish Architecture, the Association of Finnish Architects, Alvar Aalto Foundation Building Information centre, the Water Association of Finland, and Fincid ry (the Finnish national committee of the International Commission on Irrigation and Drainage).

The Sotera Institute is a research unit developing elderly living and health care facilities in collaboration with Finnish municipalities and hospital districts. It is well known among decision makers in the health care sector.

Research and Artistic Environment

Aalto's living environments area has active collaboration with dozens of cities in Finland, including Helsinki, Espoo, Vantaa, Tampere, Turku, and Lahti. This collaboration spans widely, including urban planning, architecture, mobility, and water resource management. With the University of Helsinki, Aalto has formed a joint Master's programme (Urban Studies and Planning) and deepened collaboration with the cities of Helsinki and Espoo through the Urban Academy.

Aalto has made the whole Otaniemi campus itself a major living lab for urban planning and development, including intensive new construction and renovation of the existing architectural masterpieces with care. As an example, the library

renovation into the Harald Herlin Learning Centre received the architecture Finlandia award in 2017.

Aalto researchers working on living environments have been active in developing computational methodologies in the field of planning and designing cities. Two research environments have been initiated to support this work, the MIT City Science Lab and the Aalto Built Environment lab:

1. Aalto joined the *MIT City Science Lab* in 2017 to jointly develop a new version of the MIT Cityscope platform for architectural co-design and as a simulation tool. With it, Aalto joined the City Science network, which includes Tongji University (Shanghai, China), Taipei Tech (Taiwan), HafenCity University Hamburg (Germany) and ActuaTech (Andorra).
2. Since 2012, the *Aalto Built Environment lab (ABE)* has hosted human-centred co-creation of the built environment.

In addition, other major infrastructure supporting Living+ research are the Aalto Ice Tank, 5G testbed, the Aalto Environmental Hydraulics Lab (EHL).

Table 17: SWOT analysis of the research and artistic environment

Strengths	Weaknesses
• Critical mass of professors and researchers combining science, technology, business, arts, architecture, and design, and holistic understanding of the problem space • Otaniemi campus as a living lab • Internationally recognized expertise QS2018 design 9th, architecture 46th place • Internationally recognized brand and alumni • Urban Academy collaboration with University of Helsinki and City of Helsinki	• Research area is large and fragmented • Lack of funding instruments for transdisciplinary work • Concept of human-centered living environments is not well known • Lack of prototyping spaces
Opportunities	Threats
• Rise of the Nordic brand • The area is experiencing rapid change because of urbanization, climate change, aging society, and rise of multiculturalism • Digitalization is breaking traditional industry silos	• Fragmented and siloed industry • Difficulty bridging gap from research to existing planning and market structures • Benefits hard to measure and come with long time lags • Disparity of political opinions on the topic

Future Potential

The collaboration at Aalto in the living environments area is still young because the Living+ Platform designed to help build these networks was only formed in 2016. We believe that our living environments need research that transcends traditional disciplinary boundaries, thus we have started to work from the grassroots toward building networks for transdisciplinary research. This takes time and will come to fruition during the 2020s.

The intensive urban development of Otaniemi, Aalto University campus development, the new west metro line connecting Aalto to Helsinki, and ring tram currently being built all open huge research possibilities related to living environments. As a living lab for new service development, technology solutions, workplace and housing design, and experimental architecture, the Otaniemi campus connects the research community and boosts interdisciplinary research on living environments. Otaniemi also hosts A Grid, one of the largest hubs for growth companies in Europe (see Case Study).

Aalto has hired many new tenure-track professors in the living environments area in recent years. Some of the most notable new recruitments during 2013-2017 were Milos Mladenovic (working especially on societal challenges and possibilities related to automatization of transportation systems), Claudio Roncoli (focus on intelligent transportation networks), and Idil Gaziulusoy (focus on design for sustainability and how to utilize design for systems transitions). Aalto has also strengthened its landscape architecture field with two new professor recruitments and begun collaborative work between water engineering and landscape architecture areas. Aalto University is also currently in the process of recruiting a Professor of Urban Economics who will be the first professor of this field in Finland.

Panel's Field Assessment

Excellence is definitely exhibited by the faculty who are involved in the Living+ Platform, but as of now, there is not enough evidence of excellence shown by networked high-profile projects or co-published papers that can be attributed specifically to the platform. The platform lacks a written coherent strategy concerning vision, wanted position, and prioritizations in the agenda of the platform. In the presented impact cases, there were impactful case studies, but most of the research shown was initiated well before the Living+ platform was started; consequently, the panel has the impression that as yet there is not enough impact associated with the last two years to assess impact. However, there is great potential for the future.

The members of the platform should be more attuned to the meaning of 'Living Lab' in Nordic and international frameworks - it is a term with specific meaning in these different contexts - and establish its position within these. A possible explanation for the lack of impact specific to the last 2 years is that it takes time to generate scientific impact in a platform like this. Two years is perhaps a too short perspective to see the scientific impact.

Related to the societal impact, the platform is a model for research that is not only socially motivated but socially configured. Living+ indicates several important challenges and commitments at the societal level; it is also a potentially transformative research/social/event environment. The social impact, despite international contacts, is largely local and national. This is an important and valid role for this platform. The fact that this platform is attracting local experts and stakeholders indicates its potential international appeal as well. It is significant that the university should recognize Living+ as an essential part of the organization, providing it with the proper resources to future growth. If Living+ wishes to retain its title 'living', it should ensure that human needs are visibly understood as encompassing gender, economic, cultural, age, and ethnic diversity. On the research and artistic environment, the panel felt great enthusiasm for the platform among the faculty, researchers, and stakeholders. We strongly believe that this enthusiasm forms the basis for much of what makes Living+ a vibrant and supportable platform. The Living+ Platform offers an attractive environment for faculty and student recruitment. The platform could benefit from stronger articulation/coherence of the research and artistic mission. Organizational ambiguity hampers the research and artistic environment. There should be clarity regarding the incentives for faculty to engage in the platform, and clarity regarding the roles of the departments and in the university. The fact that there is a faculty member with a near full-time commitment to this platform is important for its success. More commitment would be better still.

Future potential

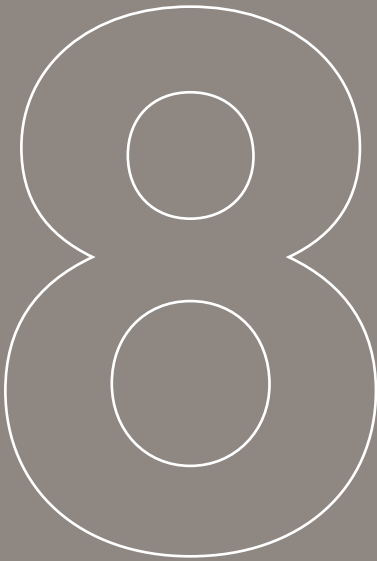
Since the platform has been active for only 2 years, it is difficult to assess individual elements. The most important points of this report are to be found in the future potential, beyond potential, and institutional areas. More immediately, the panel feels strongly that it is too early to evaluate the outcomes of Living+.

The best thing about Living+ is that it offers the university and its schools a *window on the world*; it proves Aalto's commitment to social values.

- The *enthusiasm* shown by those involved in the platform bodes well for its future; there is palpable drive to make it work.
- *This platform encourages collaboration* and a strong research network; it is actively building relationships and engaging local stakeholders.
- The platform is unique in its *direct relevance to local government stakeholders* and to local communities. This is impressive and should be encouraged.
- The *university must invest* in this platform to make it more than a collaboration facility and to help realize its full potential.

Beyond Potential: Summary of panel feedback for development:

- Living+ has yet to establish methodological clarity that does justice to the research objectives.
- Living+ has yet to get buy-in from all of Aalto's departments.
- Living+ needs to gather more industry (and government) stakeholders.
- Living+ needs to formulate strategic goals, sub goals, and sub platforms and articulate where it wants to be in 5-10 years.
- Living+ is looking at 'human engagement' through technologically-driven lenses; it should not forget the actual human subject nor the role that design plays in that appreciation.
- The four goals of Living+ - human-centered design and planning, urban life, inclusive environments, and technological breakthroughs - are admirable but there is not enough evidence that they are all equally encouraged; the emphasis on 'urban' might exclude other dimensions of society.
- The ethical dimension of research on 'living' and on humans needs to be systematically addressed.
- The questions Living+ chooses to address can benefit from a wide range of voices at the research level; input from women, the elderly, young, and representatives of minorities through design processes (workshops, questionnaires, interviews, etc.) is essential.
- There is not enough research support from the university to ensure success.
- To increase activity in the platform and its ability to attract both participants and funding, the university could do more to stimulate attention and enthusiasm. More financial and administrative support from the university.



Field: 8
Innovation Ecosystem

***Susan Marlow, Chair;** Sjaak Brinkkempe; Randi Lunnan;
Jonathan Wareham; Paul Gough; Manuel Damásio; Phill Dickens;
Robert Pelton; Marta Sanz-Sole; Salvador Carmona*

Field Description

The innovation ecosystem actors comprise Aalto researchers, students and staff, other research institutions (e.g., VTT), collaborating companies, as well as private, public, and third sector actors advancing innovation and entrepreneurship activities and processes. The innovation ecosystem activities carried out by Aalto include research-based innovation, IP creation and protection, entrepreneurship capacity building, community building, and startup acceleration. Aalto's student entrepreneurship community runs a variety of entrepreneurship-related and startup acceleration programmes. External actors active in mentoring, community building, and incubation include our alumni, the City of Espoo, European EIT KICs, the European Space Agency, and the United Nations. The Otaniemi campus acts as a hub for the innovation ecosystem, collecting incubators, accelerators, venture capitalists, and investors to serve academic innovation and entrepreneurship as well as startups and companies nationwide. Building on our unique profile, combining science and art with technology and business, we facilitate a structural reform of the national industrial base and target a leading position in Northern Europe measured by our capacity to create new businesses and growth.

Focus areas

Multidisciplinary research fostering innovation and entrepreneurship

- Multidisciplinary, innovative research facilitated by research platforms and shared, open research infrastructures, targeting IP creation and protection
- Technology and knowledge transfer including Professors of Practice as well as corporate and societal partnerships
- Global, European, and national academic networks and collaborations

Entrepreneurship as a cross-cutting theme

- Entrepreneurship research and education
- Entrepreneurship programmes
- Entrepreneurship as part of multidisciplinary education
- Startup support, startup community building, and startup acceleration
- Student entrepreneurship community and startup acceleration programs

Otaniemi campus as an innovation hub

- Thematic research/education centers with shared spaces for external academic and non-academic actors or collaborators
- Collaborative initiatives including research and innovation, Aalto and external actors
- Inspiring the next generation through collaboration with schools

Highlights (cumulative 2013-2017)*	
Number of invention disclosures	729
Number of patent applications **	333
Number of granted patents	93
Number of technology transfers	42
a) technology transfer deals excluding commissioned research	115
b) number of inventions transferred based on commissioned research agreements (number of commissioned projects with companies; in these projects the research project is planned together with the company and the company gets ownership or access rights to the results)	1041
Funding from private companies	€74m
Share of company funding of total income	4%
Startup companies created annually within Aalto Innovation ecosystem (2010-2014)***	≈ 70
Number of Adjunct Professors and Professors of Practice	124
Number of Executives/Artists/Designers in Residence	51
* The Finnish legislation grants ownership of research results to the academic personnel when results are created as part of university-funded research, and to the students when results are created as part of the study process. Thus the total number of patents is larger than those filed under Aalto and reported here. ** Including provisional applications. *** Source: Tuisku Suomala, MSc Thesis (2016); similar study ongoing by Pirkka Sippola (2018).	

Adopting a national role. Aalto was created in 2010 as a foundation-based university, through a collaborative effort of Finnish industries and the government of Finland, to strengthen the nation's innovative capacity through first-class research and thereby generate economic growth and wellbeing in Finland as well as globally. Aalto's mission to build an *innovative society* includes developing the local innovation ecosystem as a national hub serving academic innovation and entrepreneurship as well as connecting startups and companies nationwide with researchers and infrastructure, investors and venture capitalists, other startups, and established companies nationally and internationally.

Multidisciplinary research environment fostering innovation and entrepreneurship. The innovation ecosystem builds on Aalto's key research areas. Research excellence, multidisciplinary, and Aalto's unique combination of science and technology with business, art and design enable creation of novel ideas to innovations and to user-friendly products commercialized with growth-oriented business plans. Entrepreneurship is a cross-cutting theme within Aalto, embedded in many research and educational activities, and involving faculty,

staff, students, alumni, and stakeholders alike. We facilitate interactions through development of collaborative spaces, corporate and societal partnerships, and academic and non-academic, national and international networks.

Targeting an internationally leading position. Well-established ecosystems around traditional top universities such as Stanford University, Massachusetts Institute of Technology, University of California Berkeley in the USA and Cambridge University in the UK as our role models, we target a leading position among innovation ecosystems in Northern Europe and a well-recognized role in the global network of ecosystems. In this competition, and under the local legislative and funding environment, we seek novel solutions and unique approaches that create inimitable value for our partners.

Peer recognition of the Aalto innovation ecosystem. Efforts and investments by Aalto faculty, staff, students, and alumni to build the Aalto innovation ecosystem have already demonstrated positive outcomes. In particular, two international independent studies address the success of Aalto University's innovation ecosystem: *Creating university-based entrepreneurial ecosystems evidence from emerging world leaders* (Ruth Graham, MIT, 2014) and the European Commission Joint Research Centre's (JRC) science for policy report, *Place-Based Innovation Ecosystems: Espoo Innovation Garden and Aalto University (Finland)* (JRC, Rissola, Hervás, Slavcheva and Jonkers, 2017) are quoted in *Figure 24* highlighting the characteristics of our ecosystem.

Multidisciplinary Research Fostering Innovation & Entrepreneurship

Aalto University aims to develop a globally competitive research environment supporting world-leading research. Aalto's key research areas are partly selected to facilitate development of research-based innovations and their commercialization. Aalto has made significant investments to support and strengthen this backbone of the Aalto innovation ecosystem.

Academic enablers for research-based innovation. Aalto research platforms (Energy 2013, Digi 2014, Living+ 2015, Health 2016, Materials 2016, Experience 2017, and Entrepreneurship 2018) support the key research areas, facilitate multidisciplinary collaborations, and offer easy access and visibility for partners. In 2013, Aalto started a programme to fund significant *research infrastructures* (Aalto Ice Tank, Aalto Industry and Innovation Infrastructure, Aalto Neuroimaging, Aalto Studios, Bioeconomy, Metsähovi Radio Observatory, OtaNano, Raw Materials, Science-IT) requiring that they are open for users within and outside Aalto at competitive cost. As this service has been valued by our partners, we



Rissola et al. (2017): "... 1) the historically evolved concentration of highly skilled human capital and research infrastructure in the region, including the ups and downs of Nokia; 2) the vision, political commitment and collaborative culture of Helsinki-Uusimaa Regional Council and Espoo City; 3) the emergence of a strong orchestrating actor, i.e., Aalto University, which, on the basis of a shared strategic vision, stimulated the synergistic activities of the various actors; coupled with 4) the leadership, strategic and crossdisciplinary thinking of the university's management; 5) a local culture of innovation and entrepreneurship cultivated through the active support to bottom-up innovative activities in the university and the wider ecosystem; 6) a focus on the potential and capability of people to inform policies and programmes; 7) financial and policy support from the central government, including the innovation agency Tekes and private firms; 8) the successful involvement of serial entrepreneurs in financing and mentoring further start-up activities."



Graham (2014): "... The immediate Aalto ecosystem is relatively contained: a 4km² area around the university site of Otaniemi, the original home of the largest of the three merged universities. This area of Espoo is Finland's major R&D centre: it is home to other higher education institutions and research institutes as well as large population of students and technology professionals. While the Aalto ecosystem is at an early stage of development – it is only three years since Aalto University was formally opened – it is emerging as a vibrant region for technology-driven entrepreneurship. The stakeholders interviewed for the case study recognised the importance of the region's pre-existing R&D base and the strong links with major companies. However, they highlighted two additional factors as integral to the ecosystem's early success: a dynamic student-led entrepreneurship movement and a university leadership that has been proactive in its support for strengthening the entrepreneurial ecosystem."

Figure 24: Citations from two recent studies of the innovation ecosystem around Aalto University.

will extend the programme to other infrastructures. Aalto recruits Professors of Practice and Entrepreneurs, Executives, and Artists in Residence to bring practical knowledge and corporate, societal, creative, and human-centric expertise to academic education, their total number exceeding 100 at any given time. Part-time (academic) Innovation Agents operate in many departments to recognize intellectual property (IP) and facilitate its protection and commercialization.

Academic services for research-based innovation. In initiation of new research projects, Aalto's Research and Innovation Services are responsible for agreements on co-funding and ownership of IP with third parties. In corporate collaboration, Aalto's partnership services facilitate developing new and main-

EXAMPLES OF COLLABORATION TYPES BY RAI FIELD	Field 1: Arts, design and architecture Collaboration with Supercell gaming company links especially to Aalto Studios infrastructure, a new digital media center being built on Aalto Otaniemi campus.	Field 2: Business and economics School of Business partner programme offers companies participation in activities connected with teaching, research collaboration, and recruitments. Fourteen companies are currently involved.
Field 3a: Chemical engineering and physics Multi-year collaboration with Andritz, global supplier for the pulp and paper industry, aims to commercialize Aalto's biotechnologies (e.g., AaltoCellTM) for the global market. Joint 5-year (€2m) pilot programme for postdocs and PhD students with Valio, the largest Finnish dairy company.	Field 3b: Engineering Collaboration with Aker Arctic marine and ice technology company is intense, facilitated by joint use of Aalto Ice Tank ice-basin infrastructure.	Field 4: ICT and mathematics Strategic partnership with SAAB contains a 10-year (€20m) cooperation agreement, focusing on sensor technology research. Aalto is a Nokia Bell Labs Distinguished Academic Partner, as a result of long-term collaboration ranging from radio science to analytics.
Field 5: Energy Close research and teaching collaboration with the Finnish energy company Fortum focuses around Fortum-operated high-voltage laboratory on Aalto's campus.	Field 6: Health and wellbeing Collaboration with GE Healthcare Finland includes equipment donations to Aalto and shared spaces for data analysis, artificial intelligence, and startup activities.	Field 7: Living environment Collaboration with Sweco, a company specialized in the built environment and industry, is centered around Sweco's recently opened work and teamwork facilities on Aalto's campus.

Figure 25: *Examples of collaboration types for all assessment fields.*

taining long-term strategic partnerships, which reach beyond the immediate research needs of the company. Corporate collaboration has deep roots in Aalto's predecessor universities, which today is seen as tight collaboration with leading industries in Finland (*Figure 25*). As new inventions are made, innovation services support the recognition (filing invention disclosures), creation and protection of IP (e.g., patenting, licensing) and transfer of rights to third parties, including newly formed startups — often involving so-called TUTL (from research to business) funding from the national innovation agency Business Finland (formerly Tekes). Accelerator and other business development services are provided for emerging startups by the Aalto Startup Center at the A Grid startup facility.

Entrepreneurship as Cross-Cutting Theme

Aalto University aims to provide every student and staff member experiences of entrepreneurial thinking and actions. A unique asset is the wide range of student-led entrepreneurship activities; the strength of the ecosystem also comes from a multitude of Aalto alumni and stakeholder contributions.

Entrepreneurship research. Aalto's entrepreneurship research is carried out in the Department of Management Studies (School of Business) and in the Department of Industrial Engineering and Management (School of Science), the latter focusing on practical entrepreneurial skills in technology.

Entrepreneurship education. Aalto's curriculum provides numerous courses including real-life cases and lectures by corporate partners. In Product Development Project (PDP) courses a problem-based learning approach is used by interdisciplinary teams working at the Design Factory to solve problems given by (manufacturing) companies. The Aalto Ventures Program (AVP) offers all Aalto students entrepreneurship courses taught by professors, venture capitalists, and entrepreneurs, with focus on building scalable businesses. Degree programmes include the Aaltonaut bachelor-level minor on product development (problem-based learning, interdisciplinary teamwork in hands-on projects, entrepreneurial attitude), Master-level major in Strategy and Venturing (strong emphasis on technology), and a Master's programme in Entrepreneurship and Innovation Management (venture ideation and formation, sustainable entrepreneurship). Aalto University Executive Education Ltd (Aalto EE) provides degree and executive programmes, and customized solutions for professional development. Aalto EE brings multidisciplinary, and arts- and design-based learning methods to 6 000 experts/leaders from 1 000 companies worldwide, with regional programmes in Poland, South Korea, Singapore, Taiwan, and Iran.

Entrepreneurship programs. Building on entrepreneurship-related collaboration with the University of California Berkeley and Stanford University - both pioneers in university-based innovation ecosystems - we have introduced the Berkeley Method of Entrepreneurship to develop new teaching models, and two health-related programmes jointly with the University of Helsinki and the local hospital district based on models from Stanford. The Biodesign Entrepreneurial programme aims at improved medical care, while the Spark Translational programme targets advancing academic discoveries from laboratory to patient care.

Student-led entrepreneurship activities. The student and startup community Aalto Entrepreneurship Society (AaltoES) organizes startup programmes and

EXAMPLES OF INNOVATION ECOSYSTEM ACTORS AND ACTIVITIES

AALTO FACULTY AND STAFF

Multi-disciplinary, collaborative research

- Research platforms and infrastructures
- Professors of Practice and other joint positions
- Corporate partnerships and joint research projects between Aalto and companies
- Aalto research platforms and other joint research initiatives

Innovation commercialization

- Services for innovation recognition and IP creation (licensing, patenting, startups)
- Startup incubation and acceleration (Aalto Startup Center, A Grid startup community and working space)

Entrepreneurship capacity building

- Entrepreneurship research
- Entrepreneurship education: individual courses, bachelor and master programmes
- Product development courses
- Executive education (Aalto EE)
- International networks (Stanford and Berkeley collaboration, Design Factory Global Network)

AALTO STUDENTS

Community building

- **Aalto Entrepreneurship Society** (AaltoES) with student and alumni involvement
- **Startup Sauna** co-working space managed by students
- **Kiuas** accelerator programme for early-stage business ideas

Entrepreneurship programs

- **StartupLifers**: Internship programme for students to work in the San Francisco Bay area.
- **Summer of Startups**: Supports teams in starting a new business with small funding, a place to work, customized coaching, and support of the startup community.
- **TeamUp**: Targets individuals interested to join or create a startup company, offering programme building, developing, coaching and evaluating teams and ideas.
- **Kiuas**: Accelerator programme focused on business idea crystallization and development.

Entrepreneurship events (> 100 annually)

- **Junction**: Europe's largest hackathon, **Dash**: design-focused hackathon
- **FallUp** and **Slush**: Events collect numerous interested (to be) entrepreneurs, investors, and partner companies. **Slush** is an annual, globally leading startup and investor event gathering about 20 000 attendees including founders, investors, executives and media from over 100 countries. A large number of volunteers (about 2 000, incl. high school students) from 50 countries build the event. **Slush** has global events in Tokyo, Singapore, and Shanghai, and tens of smaller local events around the world.

INTERNATIONAL NETWORKS AND ACTORS

- **European Union EIT Knowledge and Innovation Centers**
(Digital, RawMaterials, Climate)
- **European Space Agency Business Incubation Center** (ESA BIC)
- **United Nations Technology and Innovation Laboratory** (UNTIL)

Figure 26: *Actors and activities of the Aalto Innovation Ecosystem.*

events (Figure 26). The Startup Sauna, a co-working space managed by students, is the main centre of AaltoES activities. Aalto supports the student activities financially and by providing spaces.

External stakeholders facilitating entrepreneurship. Active participation and mentoring by Aalto alumni and collaborators, who are experienced entrepreneurs and hold key positions in society, has been a major element of our success. Most notably, Ilkka Kivimäki (investor in early-stage entrepreneurs, partner in Maki.vc) and Risto Siilasmaa (Chairman of the Board of Nokia and F-Secure) have played a key role in bringing all ecosystem actors together and developing a joint vision. Furthermore, the Aalto ecosystem attracts national and international companies, institutions (European Space Agency, United Nations) and public actors (City of Espoo) to bring their innovation activities on campus (Figure 26).

Otaniemi Campus as an Innovation Hub

Aalto develops the Otaniemi campus toward an open and experimental collaboration ecosystem that attracts students, faculty, staff, and partners worldwide. The campus and state-of-the-art research and learning environment supports production of new knowledge and innovation, and offers opportunities for partnering, collaboration, and sharing ideas and experiences.

Facilities and shared spaces. A Grid is a recently established community and working space on Aalto's campus. The 25 000m² facilities include startups, accelerators, creative businesses, maker's spaces, and open work space. A Grid hosts the European Space Agency Business Incubation Center (ESA-BIC), the United Nations Technology Innovation Labs (UNTIL), and the Aalto Start-Up Center (ASUC). ASUC is the largest business accelerator in Finland, and it provides pre-acceleration services for research teams to commercialize innovations and accelerator services for startups (office facilities, mentoring services, development and coaching programmes, training, networking, and events). Aalto Design Factory (ADF), hosting the Product Development Projects and other interdisciplinary courses (~40 courses annually), is a co-creation space for students, researchers, entrepreneurs, and companies with the aim to produce world's best product designers. The concept of ADF has been exported to over 20 locations on five continents to build the Design Factory Global Network. The Startup Sauna, a co-working space managed by students, with strong input from alumni, is the main center of AaltoES activities.

Multi-party collaborations. Aalto Industrial Internet Campus offers an open experimental platform for joint research projects between Aalto and companies

(core industrial partners ABB, Elisa, Ideal PLM, Konecranes, Nokia). The Finnish Center for Artificial Intelligence seeks increased use of AI in industrial and societal applications (~15 company partners and several research institutions). The Aalto Bioproduct Centre includes facilities for research, teaching, and collaboration providing a 'factory of the future environment'. Bioeconomy (bio-based chemicals, fuels, materials, and fibre products; ~20 company partners) and OtaNano (micro, nano, and quantum technologies) infrastructures are operated jointly with VTT Technology Research Center of Finland. Aalto's campus hosts co-location centres for EIT Digital and EIT Raw Materials, and a hub for EIT Climate KIC. These European Institute of Innovation and Technology Knowledge and Innovation Communities bring together leading European universities, research labs, and companies to form partnerships that develop innovative products and services, start new companies, and train a new generation of entrepreneurs.

Collaboration with local cities. The City of Espoo, the home base of Aalto's campus, has offered to act as a pilot platform for the university in urban development or smart and clean technologies, for example. Urban Mill, operated by the City of Espoo in collaboration with Aalto, is a co-creation space, thematic community, and a service bringing stakeholders together to create enhanced urban living through new innovations. Collaboration with the City of Helsinki focuses on health and wellbeing solutions (Health Capital Helsinki), hospital building solutions (Sotera institute), issues related to urban planning (Urban Academy), and development of the local and global economics (Helsinki Graduate School of Economics).

Community building activities targeting youth. Aalto hosts two City of Espoo high schools on campus under the framework of School as a Service with shared use of spaces and frequent interaction with Aalto faculty and students. The first startup founded by high school students is already under the auspices of the Aalto Startup Center. In addition, Aalto Junior offers activities to schools and children.

Societal Impact, Entrepreneurial and Innovation Capacity

Aalto University aims at high societal impact for the benefit of economic growth and welfare, both nationally and globally. Our ambitious aim is to combine world-class fundamental research with efforts to transform the results to practical applications and economic value. Aalto's innovation ecosystem has a key role by creating opportunities and incentives both for research and application development. Aalto continuously evaluates the societal impact that the ecosystem development makes.

The societal impact of the Aalto innovation ecosystem is multifaceted,

including economic, artistic, and cultural impact, as well as impact on welfare, environment, sustainability, public policies, and discussion. Aalto's graduates and alumni are *game changers*, who are well equipped to target challenging problems and find out-of-the-box solutions. Aalto's impact indicators include: the number of co-publications with companies; the level of external corporate funding; the volume of commercialization projects; the number of startups, spinouts, patents, licensing, and other IP transfer agreements; and the value of business created. We also monitor the number of companies and other stakeholders present on campus and the number of collaborative research projects with companies and other external stakeholders. For education, we follow the employment of graduates at Master's and doctoral levels.

Metrics to Quantify Short-Term Societal Impact

Corporate collaboration. We measure the outcome of this essential element of the ecosystem by the number of joint publications with industry (8% in 2017 CWTS Leiden ranking) and research funding from private companies (€13m; 4% of the university budget in 2016, see *Figure 27*). In both metrics, Nokia stands out as the most significant partner. During 2012-2016, the national research partners having more than 100 joint publications with Aalto include Nokia, VTT Technology Research Centre of Finland, and six universities. The top-10 partner companies in terms of income to Aalto (in 2016) are Nokia, VTT, Neste Oil, Valio, ABB, Omya Group, UPM-Kymmene, Outotec, Metsä Group, and Stora Enso.

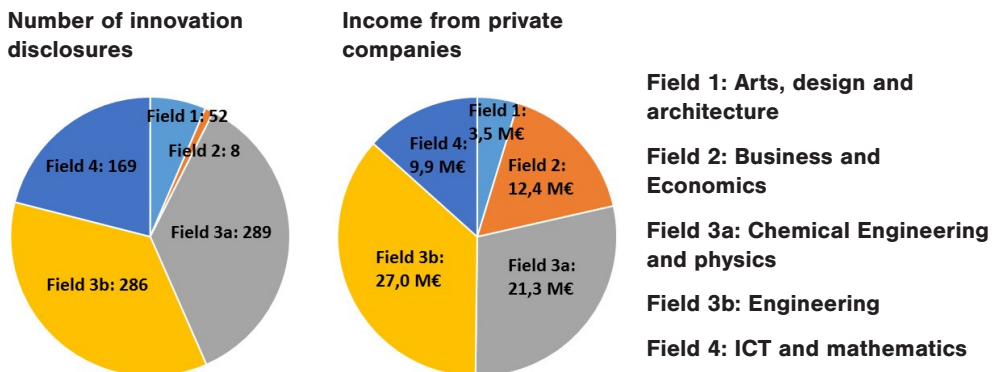


Figure 27: Distribution of invention disclosures 2013-2017 and income from private companies 2013-2017.

New business creation. National innovation funding awarded by Tekes (Finnish Funding Agency for Innovation; Business Finland 2018-) has been a major source for funding collaborative research projects (€23m; 6% of the university budget in 2016). Aalto has been a major recipient of that funding (25% of the total granted by Tekes to universities). Tekes funding instrument TUTL - New business from research ideas, intended for the preparation of research result commercialization, is important for new business creation: Tekes has granted Aalto 46 projects totaling more than €21m (2013-2017).

IP creation. Aalto University *Principles for Commercialization of Intellectual Property* (2017) define the primary aim in IP commercialization to maximize societal impact through optimal utilization of the results. In the assessment period (2013-2017), the number of Aalto-affiliated invention disclosures is 729, patent applications 333 (including provisional applications), and granted patents 93. Technology transfers include 42 deals, excluding commissioned research and 115 inventions transferred based on commissioned research agreements, where the partner company has ownership or access rights to the results. One should note that Finnish legislation grants IP ownership to university researchers, which results in research-based IP not affiliated with or tractable by Aalto.

Startup creation. About 70 startups arise from the Aalto ecosystem annually (2010-2014), and the number has been around 100 in recent years. A recent success story comes from Aalto's Space Science and Technology programme, when the ICEYE startup received €16m investment in SAR microsatellite technology and successfully launched Finland's first commercial satellite into orbit in January 2018.

Elements that will Contribute to Long-Term Societal Impact

Attracting talent, entrepreneurial activity, and investments. The long-term impact (not measurable yet) of the Aalto innovation ecosystem will be powered by collaboration between multiple diverse actors, facilitated by A Grid and other collaboration platforms and processes. Aalto's improved academic performance (publications, citations, rankings) has a crucial effect on the attractiveness of the research environment, bringing new (international) talent to the innovation ecosystem. Student-led entrepreneurial activities attract talented students, entrepreneurs, and investors. International organizations, such as the ESA-BIC, UNTIL, and EIT KICs, link us to international academic and corporate communities.

Renewing Finnish industry. The Aalto ecosystem including Finnish and international companies has produced new products, services, and solutions, which

have potential for groundbreaking and transformative market effects. Aalto has recently strengthened its collaboration with Kone, Fiskars, Wärtsilä, Kesko (supermarket and other retail), Elisa, Finnish Marine Industries, and Technology Industries of Finland.

Serving the local cities Helsinki and Espoo. Already, Aalto contributes widely to social development, industrial growth, education of the workforce, and local and national decisionmaking in the Helsinki metropolitan area. Recent agreement with the four cities in the capital area, Aalto, and the University of Helsinki fund a professor and six postdoctoral researchers focusing on urban economics and other issues related to urban development. In the SWOT analysis in *Table 1*, we address issues affecting ecosystem development and outputs to society.

Table 18: SWOT analysis of the Aalto innovation ecosystem

Strengths	Weaknesses
• High quality research and education • Research collaboration spaces and networks involving academics and corporations • Campus as a collaboration hub • Strong student entrepreneurship activities • Strong traditions in corporate collaboration • Active alumni mentoring and participation	• Varying level of expertise and interest in knowledge transfer among Aalto personnel • Academic personnel lack incentives for innovation and ecosystem activities • Finland lacks funding instruments for technology development/proof of concept
Opportunities	Challenges
• Expertise in research areas with potential for transformative disruptions • Diverse national and international two-way interaction between university and society • Global reach of activities	• Recruitment and retention of top talent • Finland's economic situation and its effects in university funding

Future Potential

Aalto's level of ambition in developing the innovation ecosystem is high, targeting a leadership position in Northern Europe and being on equal footing with globally well-established ecosystems around top universities identified here. This will require seeking novel solutions and unique approaches to create value our partners cannot get in other ecosystems, and building on such strengths as entrepreneurship education and student-led entrepreneurship. The creative ecosystem development will go hand-in-hand with the increased international standing of Aalto University's academic research and education.

Campus development offers opportunities to create topical hubs focusing on particular fields. Aalto University plans to further increase the attractiveness of the campus by increasing infrastructure investments (goal: 4% of the annual budget), and by opening our infrastructures for wider academic and nonacademic use. Aalto's significant infrastructures target international significance, for example ESFRI status. Furthermore, Finnish participation in large international infrastructures (such as European Space Agency, European Southern Observatory, Conseil Européen pour la Recherche Nucléaire or CERN, International Thermonuclear Experimental Reactor, and European Molecular Biology Laboratory) often opens doors for ambitious research and development projects, which benefits partnership development and provides a future reference for companies.

The creative industry is growing fast and significantly contributes to finding solutions to societal and economic challenges. Competitiveness and employment in other sectors can be significantly improved by drawing on the creative sector's digital and customer-centred business models, design, service design, and branding competence, and marketing and communication competence more extensively in all areas of the Finnish economy. By investing in the creative sectors and utilization of creative competence, diversification of the economic structure can be accelerated, exports can be promoted, and the added value of production can be increased. To increase the visibility and impact of art, design, and creativity in renewing society, we have a thorough, diverse set of university wide activities: University-Wide Arts Studies (UWAS, open to all Aalto University students), the Experience Platform to promote interdisciplinary activities in designing experiences in the contemporary and future world, Artists in Residence placed in schools of technology and business, investments in works of art on campus (1% of the cost of buildings is used to purchase works of art). Also, Aalto Studios will provide unique facilities for creative industries and use of technological innovations to fulfill artistic needs serving the digital society at large.

The European Union 9th Framework Programme, including the European Research Council (ERC) grants for academic and proof-of-concept research, plans for the European Innovation Council, and the EIT KICs all offer occasions for international networking, ambitious research activities, and corporate collaborations. Furthermore, the growing Asian market and our international faculty and students with contacts and networks to those markets provide new openings for the entire ecosystem. This will be further facilitated through ongoing efforts to strengthen and develop strategic partnerships with universities in China, South Korea, India, and Singapore, for example, Aalto University recently established the Shanghai International College of Design and Innovation in cooperation with Tongji University. All Aalto activities aim at creating a sustainable society. Aalto University is a signatory of United Nations Sustainable Development Goals

Accord, which calls for 'embedding sustainable development goals in education, research, leadership, operations, administration and engagement activities'. Aalto University's Sustainability Hub collects and facilitates actors and activities related to sustainability. Aalto University is also founding member of the Smart and Clean Foundation set up by Sitra (Finnish Innovation Fund), developing smart and clean solutions for products, innovations, their export and sales, as well as public tendering. The UNTIL project, located in A Grid, will also have a strong focus on education, the circular economy, and health, all based on Sustainable Development Goals.



Panel's Field Assessment

Excellence: Excellent achievements over a short time

Aalto has a vibrant and diverse local innovation ecosystem in and around the campus but also a national hub with international reach. Entrepreneurship is a cross-cutting theme underpinning the innovation hub. This networked ecosystem also lays the foundation for numerous initiatives to promote entrepreneurial activity in the form of new venture creation and platforms for ideation. Success has been recognised and endorsed by two international independent studies, providing evidence for Aalto as a leading innovation ecosystem within Northern Europe.

Collaborative mechanisms exist both within the university and beyond. Internally, these are facilitated by a series of research platforms: Energy established in 2013, Digi 2014, Living+ 2015, Health 2016, Materials 2016, Experience 2017, and Entrepreneurship 2018. In each of the seven fields of research, there is evidence of collaboration both within and outside the university; some more mature than others. The ICT field has a strong partnership with SAAB developed over a 10-year cooperative agreement valued at some 20 million euros. An important asset is the wide range of student-led entrepreneurship activities on the Otaniemi campus that attract students, faculty, staff, and partners worldwide. These are encouraged and developed through a wide number of initiatives that cover idea events, venture creation support, incubation, pitching events, et cetera. The engagement of students to lead and manage such initiatives is impressive. In addition, the ecosystem reaches into Finnish cities through collaborations with Helsinki that focuses on health and wellbeing solutions (through Health Capital Helsinki), and hospital building solutions (with Sotera Institute), as well as urban planning, with the Urban Academy.

Significantly, for its international reputation Aalto hosts the European Space Agency Business Incubation Centre (ESA-BIC) and the United Nations Technology Innovation Labs (UNTIL). Taken together, this combination of high-profile research and infrastructure has brought about international recognition, such as that from MIT (Graham 2014), which considered the Aalto ecosystem as 'the rising star'. The case study presentations were valuable illustrations of the support offered to young firms and the quality of these offerings. Implementation varies by area, more advanced in areas like ICT or chemistry compared to those like the arts. The level of multidisciplinary can be increased – probably the greatest challenge to the ecosystem. Interesting examples are put forward – the case of games – but the fact that information is presented in 'silos' adds to the impression that the ecosystem stills supports innovation on a disciplinary base while entrepreneurship, although a cutting theme, is used by each discipline to

promote its own knowledge transfer processes.

The number and diversity of startups created is impressive; student engagement in managing initiatives such as Slush is an excellent example which should be used for other universities. The ecosystem whereby staff have empowered students to manage this programme is clearly reaping results. However to fully judge the efficacy of the ecosystem, a concerted effort is required to collect hard data regarding substantive startups, their sustainability and scalability over time. Without such data, it is difficult to fully evaluate the effectiveness of the ecosystem in enabling the creation of sustainable enterprises that go forward with international reach and other long-term benefits, such as secure employment creation. Such evaluation and data collection may be hampered by the diversity of the ecosystem given the plethora of initiatives which, for the external observer, are difficult to disentangle in terms of overlap and duplication. Clearer strategic 'ownership' of the whole matrix of these initiatives at a senior level may be helpful to avoid confusion and engender greater coherence in the current offering, and so further strengthen the foundations of the ecosystem. Such a strategic overview may also facilitate the incorporation of KPIs to gauge some degree of return on the extensive investment that has been made into developing this ecosystem. There is considerable focus on students, particularly undergraduate and MSc, enterprise - evidence suggests there is greater value added potential in academic spinoffs in conjunction with doctoral students and postdocs, this requires further consideration.

Impact: Not entirely in terms of links to research

Unlike other fields, we cannot conduct this assessment on research, funding, citation, or community of practice (editorships, etc.) criteria. It is thus a more diffuse assessment around startups et cetera that does overlap with the categories above and below. Evaluation of the value chain is well measured in the university; the metrics available to view and through the case studies include the volume and number of co-publications with companies; the level of external corporate funding; the volume of commercialization projects; the number of startups, spinouts, patents, licensing, and other IP transfer agreements; and the value of business created. The metrics are available from 2017, for example, joint publications with industry were 8% in 2017 CWTS Leiden ranking, and research funding from private companies was €13m; 4% of the university budget in 2016. This offers substantive evidence for impact. Industry engagement is at the heart of the university's vision, mission, and strategy. In terms of income to Aalto in 2016, it lists several corporate partners. The impact of the Innovation Ecosystem is measured through a two-tier scale, which provides data about short-term and long-term performance. The results are significant concerning the short-term

metrics. Obviously, the ecosystem is now building for the future, and long-term performance metrics cannot be properly assessed. As far as short-term performance measures is concerned: (i) corporate collaboration: top Finnish companies are engaged in the ecosystem, (ii) Aalto's ecosystem receives 25% of total funding granted by Tekes to universities, (iii) IP creation, see above. Concerning long-term actions: (i) attracting talent, entrepreneurial activity and investments, the results are still on the way as this is clearly a long-term action; (ii) renewing Finnish industry: there are already promising results, and (iii) serving the local cities: cooperation has resulted in agreements to fund faculty positions and postdoctoral researchers. Data is presented on patents, et cetera, how these are actually enacted would generate more robust data on actual impact from the ecosystem. The case study presentations were impressive, illustrating the diverse nature of impact in terms of innovating processes and products but also prompting international engagement and interest. The nature of the ecosystem with emphasis upon innovation and entrepreneurship has also had an impact on the pedagogical basis of teaching and learning, not only through the adoption of teaching practical entrepreneurial competencies but also developing more entrepreneurial mindsets whether students go into corporate or self-employment. Evidence of engagement with local policy development also suggests some leverage in public policy development to support the existing ecosystem but also to build foundations for it to be replicated in other sites and organizations. The degree of excellence in the ecosystem has, as noted above, enabled the creation of numerous new ventures, ideation opportunities, business planning competitions, et cetera. Our observation regarding the lack of data and evaluation, however, is echoed here.

Societal impact: Strong eco structure to encourage student innovation and enterprise

There is evidence from the material submitted of significant Finnish Funding Agency for Innovation Tekes (Business Finland 2018-) funding, which was valued at €23m in 2016, which is 6% of the university revenue. Tekes funding instrument TUTL - New business from research ideas, intended for the preparation of research result commercialization, is important for new business creation. Tekes has granted Aalto 46 TUTL projects, €21m between 2013 and 2017.

This is a significant achievement. The data on corporate collaboration provided in the self-assessment document demonstrate that Aalto is a highly valued partner in Finland. Metrics relative to intellectual property and startup creation provide convincing evidence for entrepreneurial activity and innovativeness. IP creation appears to be very lively with significant achievements - 729 invention disclosures, 333 patent applications, and 93 granted patents. Technology transfers include 42 deals. The ecosystem is enriched by up to 70 early stage startups in a four-year

assessment period. *Figure 27* indicates the spread of activity and income across the fields, which does need comparators with other European universities in order to deduce international standing.

It was, however, surprising to see no mention or analysis of social enterprise or social innovation - issues of great contemporary importance but not acknowledged here. It is clear that Aalto has national-level impact as university-level institution in this field in Finland. It sets the benchmark as the forerunner, tester, and catalyser of emerging trends of its fields — both technologically and artistically. The A Grid is influential here with a high level of tenancy; the Aalto Design Factory is also supporting innovation in this sector whilst the Design Factory Global Network is already formed with 22 universities and research institutions. Importantly, it promotes high-quality education; a co-creation platform for students, faculty, and industry; and the co-creation of facilities, practices, and eco-systems. Finally, Slush offers a strong example of societal impact to encourage and support new venture planning with events offered on an international basis.

Although there is reference to artistic impact, all measures considered are more of an economic and business related nature. The Design Factory suggests artistic impacts but the manner in which the case is presented actually resonates more with an interesting use of design thinking for new business development. Sustainability seems to be the core issue for the ecosystem. In this domain, IP management practices can be crucial for the future in assuring the ecosystem also benefits from the knowledge it generates. Defining measures to assure this is crucial; the university should actively try to change the policy in place that diminishes its ability to explore internally generated IP.

Of the three areas of intervention in the long term – industry, region, and talent – this last one seems to be the most complex, but the fact that high-profile international institutions are associated with Aalto (ESA, EIT KICs, etc) can facilitate attracting top international talent. As an example of societal impact, it would have been useful to see more evidence for actual contributions at the societal level even in crude indicators, such as employment created - there is evidence of patents registered but many of these will come to nothing. Further data on number of companies located on Aalto's campus and related employment and turnover details would offer clear evidence regarding the efficacy of the societal impact. Much of the impact discourse relates to the local area and economy: sharing the practices that have created the ecosystem with universities in developing countries would enhance international impact.

Research and Artistic Environment: Needs to span gulf between research potential and practical outcomes

There seems to be a very strong infrastructure for innovation in both hard

(e.g., buildings) and soft (e.g., networks) aspects. The strengths of the innovation ecosystem are the coexistence in the campus of high expertise in arts and sciences, design, technology, and business at the service of innovativeness for entrepreneurs and established companies. Obstacles that may prevent the unit from realising its full potential are the lack of incentives to embark in ecosystem activities and the varying level of expertise and interest in knowledge transfer of the academic staff. There is a robust SWOT analysis which identifies how the combination of arts and sciences, design, technology, and business is well connected with research and education across the university; it is clear, however, from the texts and case studies that this does appeal to early-stage entrepreneurs and established companies. It is impressive to see the commitment of alumni in contributing to the ecosystem, though this does put a strain on existing staff resources as there is varying level of expertise and interest in knowledge transfer among Aalto staff. Amongst the challenges is the ability to attract venture capital investment in scale, the ability to attract top talent and retain, but there are also opportunities to grow diverse national and international two-way interactions between the university, its innovative disciplines, and society.

The innovation ecosystem combines avant garde research, which is conducted by academic units in other fields (e.g., Field 2) and a commitment to arts, design, and creativity. The Aalto ecosystem is one of the few cases where one can see that such an ambitious approach results in tangible outcomes. The understanding of entrepreneurship as a core transversal competence is clearly the main strength of the environment. This results in many different and interesting outcomes that can support innovation, such as the integration of entrepreneurship education in the university syllabus and the conception of the campus as a hub. Other derived positive aspects result from the active integration of alumni in mentoring and business developed processes. Although mentioned in the self-assessment report, it is not clear that a strong tradition of corporate collaboration exists. We note gaps between the potential of the ecosystem as a site for research activity and actual academic activity in terms of mining this environment. Relatedly, a research partnership relationship within the creative industries should be generated that moves beyond the creative hub just becoming a service provider to external users.

Future potential: Needs strategic direction to further realise scope

Aalto's innovation ecosystem has the potential to be among the university's top impact activities and reach a leadership position in Northern Europe. The plans for the future are ambitious and need a strong commitment from the university in terms of funding academic staff but also dedicated business support staff, IT experts, and expansion of the network of external contributors to generating an entrepreneurial ecosystem that combines research with practice illustrated by

outcomes that generate sustainable changes. The university has a particular edge in being able to draw upon its reputation in creative industries, media, and design to draw on the creative sector's digital and customer-centered business models, design, service design, and branding competence, and apply the methods and processes extensively in all areas of the Finnish economy. To do so, the university has set aside a portion of the annual budget but will clearly need to do more to scale up and become a global competitor. A number of initiatives are also mentioned that are already in place and to be developed in the future in the area of the arts; namely the Experience Platform, designed to promote interdisciplinary activities, but this requires a strategic vision to drive it forward.

To assure success is reached, it is insufficient to just introduce entrepreneurship-related subjects. One must also convince academics and students of the relevance of the subject – something that does not seem to be easy considering the negative comment on the teachers' willingness to get involved in entrepreneurial actions mentioned in the SWOT. Most of the infrastructure is large scale with potential in terms of research but the potential in terms of generating new sustainable businesses requires consideration. Given the focus on developing this innovation hub, if the university can attract appropriate academic staff, continue to expand practitioner expertise, and demonstrate how student enterprise can be converted to sustainable outcomes in a context of secure funding and long-term input from corporate/international partners, there is much potential here. However, the potential to build upon what has already been achieved now requires clearer strategic direction to bring coherence to the plethora of programmes and initiatives that run parallel but also have degrees of overlap. There must be KPIs developed, and regular evaluation to assess what value this ecosystem actually adds in terms of sustainable ventures, so levels of failure and closure have to be acknowledged as does employment created, wealth generated, and how this impacts local and national contexts. This also needs to be enhanced with more data on student employability and their career choices; there is also scope for supporting academic spinoffs and leveraging more value from doctoral student innovations. Overall, hard data is now required, combined with more coherent strategic leadership to move to the next level.

Overall assessment: Impressive with scope for future development.

Recommendations for the multidisciplinary field Innovation Ecosystem

Positive points

1. Scope and scale
2. Strong commitment from central university management
3. Excellent facilities; diversity of business creation/support initiatives;
4. Student-led activities (Slush)
5. Multidisciplinary input
6. Patents, new venture creation record
7. Creative industries/design impact
8. Embedded entrepreneurship education

Recommendations

1. Confusing offering; eliminate duplication and repetition
2. Provide better navigation through the confetti of initiatives
3. Collect more data on the sustainability and added value of venture creation
4. Initiate strategic ownership; establish KPIs,
5. Organize additional support for copyright and design-right in the areas where patents are not possible
6. Reflect on the balance of initiatives aimed at student-driven entrepreneurship versus science-based entrepreneurship by professors, PhDs, and postdocs



Appendices: Elements of assessment, Panels, Assessment Organization

Appendix 1:

Numerical ratings and written statements

Excellence, Quality, and Multidisciplinary Collaboration of the Research and Artistic Activities

The panels are asked to assess all research and artistic work, whether fundamental or applied, topical, or multidisciplinary, with equal weight. The written comments shall address the quality and excellence of the activities as well as the scope and success of the multidisciplinary activities.

Impact of Research and Artistic Activities on the Scientific/Artistic Community

The panels are asked to assess the impact of the research and artistic activities in terms of international leadership, influencing global research/art directions, citations, reach of the artistic work and activity, taking part in international dialogue, and contributing to the development of the fields of research and artistic activities.

Societal Impact, and the Entrepreneurial and Innovative Capacity

The panels are asked to assess the societal impact of the units in terms of their influence on change, benefit, or value added to the economy, society, culture, public policy or services, health, the environment, or quality of life, beyond academia. Impact also includes reduction or prevention of harm, risk, cost, or other negative effects. Impact of the research and artistic activity may appear as or lead to:

- Societal quality (e.g., interaction with and communicating results to external stakeholders, engagement in entrepreneurial activities).
- Societal impact (e.g., influence on stakeholders or societal procedures).
- Valorization (e.g., activities aimed at making results available and suitable for application in products, processes, and services, utilization of innovation potential).
- Dissemination (e.g., activities aimed at making results widely known or providing stakeholders a window to current research and novel results).

Societal impact is demonstrated by case studies provided by the units of assessment. In the case studies, both quantitative and qualitative impact indicators shall be considered. Such indicators include but are not limited to expert tasks, popularized works, media visibility, activities, and external funding resulting

from collaboration with non-academic institutions (corporations, Tekes, EU), invention disclosures, patents, licenses, startup companies, cooperation with the public, private, and third sector outside academia, and involvement in training programmes for leaders and executives. Panels are also asked to assess how the unit is developing its strategy to support and enable impact of its activities.

Research and Artistic Environment

The panels are asked to comment on the research and artistic leadership and long-term strategic planning of the unit's research and artistic activities, including human resources strategy and the focus of research/artistic activities. Further indicators include but are not limited to international networks and collaborations, availability and quality of support services, research and artistic infrastructures, databanks, technical staff, and the ratio of students to teaching personnel, and the ratio of administrative to academic personnel.

Panels are asked to identify assets of the research and artistic environment that require further strengthening and structural obstacles that prevent the unit from realizing its full potential. Although the panels are not asked to evaluate individual researchers, they are invited to identify particular strength areas and the balance of the overall research profile of the unit and of the university as a whole.

Future Potential

The panels are asked to comment on the future potential and academic leadership within each unit. The assessment shall consider the potential of:

- Researchers, engineers, and artists in international competition.
- Research and artistic environment to provide support for the chosen activities.
- Making an international level impact on the research/artistic community and/or society.
- Emerging research or artistic fields.

The assessment may include but is not limited to such indicators as the vision and plans for the future, plans on utilizing the multidisciplinary opportunities at Aalto University, the level at which the unit recognizes its strengths and weaknesses, emerging future opportunities and challenges, and the plans for managing such factors. Issues, such as age and career profile of the faculty and staff, the size of the unit, and the ability of the unit to attract high-quality and international doctoral students and faculty may play a role. Panels are invited to comment on the unit's infrastructure and the investments needed in the future to maintain its attractiveness. Further indicators may include the ability to secure competitive funding, the capacity to focus the unit's research and artistic activities on timely issues, or the existence of international collaboration networks.

Appendix:

Panels

Field 1: Arts, design and architecture

Paul Seawright, University of Ulster, Chair

Peggy Deamer, Yale School of Architecture

Paul Gough, Royal Melbourne Institute of Technology (RMIT University)

Kees Dorst, University of Technology Sydney

Manuel Damásio, University of Lusófona

Susan Kozel, Malmö University

Field 2: Business and economics

Marno Verbeek, Rotterdam School of Management, Chair

Peter Norman Sorensen, University of Copenhagen

Salvador Carmona, IE University Madrid

Randi Lunnan, BI Norwegian Business School

Thorsten Hennig-Thurau, University of Muenster

Steve Brown, Southampton Business School

Daniel Guide, Pennsylvania State University

Susan Marlow, Nottingham University Business School

Jonathan Wareham, Esade Business School

Field 3a: Chemical engineering and physics

Heiner Linke, Lund University, Chair

Emiel Hensen, Eindhoven University of Technology

Arno Villringer, Max Planck Institute for Human Cognitive and Brain Sciences

Daniel Loss, University of Basel

Pär Jönsson, KTH Royal Institute of Technology

Erling Halfdan Stenby, Technical University of Denmark

Jan Lagerwall, University of Luxembourg

Robert Pelton, McMaster University

Lisbeth Olsson, Chalmers

Field 3b: Engineering

Kamal Sarabandi, University of Michigan, Chair

Carlos Guedes Soares, University of Lisbon

Rachelle Alterman, Israel Institute of Technology

Daniel Loucks, Cornell University

Paulien Herder, Delft University of Technology

Ragnar Larsson, Chalmers

Phill Dickens, University of Nottingham

Oliver Brand, Georgia Tech
Marcian Cirstea, Anglia Ruskin University
Jan Wikander, KTH Royal Institute of Technology
Choongsik Bae, KAIST

Field 4: ICT and mathematics

John Lafferty, Yale University, Chair
Muffy Calder, University of Glasgow
Marta Kwiatkowska, University of Oxford
Maria Sabrina Greco, University of Pisa
Thushara Abhayapala, Australian National University
Susanne Boll, University of Oldenburg
Sjaak Brinkkemper, Utrecht University
Marta Sanz-Sole, University of Barcelona
Andrew Odlyzko, University of Minnesota

Chairs and panel members for the multidisciplinary Fields 5-8 were assigned from panel members for Fields 1-4:

Field 5: Energy

Paulien Herder, Chair; Choongsik Bae; Carlos Guedes Soares; Marcian Cirstea; Erlin Stenby; Peter Norman Sorensen; Daniel Guide; Lisbeth Olsson; Pär Jönsson; Emiel Hensen

Field 6: Health and wellbeing

Arno Villringer, Chair; Marta Kwiatkowska; Oliver Brand; Jan Wikander; Susanne Boll; Thorsten Hennig-Thurau; Jan Lagerwall; Steve Brown; Daniel Loss; Muffy Calder

Field 7 Living Environments

Peggy Deamer, Chair; Rachelle Alterman; Kees Dorst; Maria Sabrina Greco; Thushara Abhayapala; Andrew Odlyzko; Daniel Loucks; Ragnar Larsson; Susan Kozel

Field 8 Innovation ecosystem

Susan Marlow, Chair; Sjaak Brinkkemper; Randi Lunnan; Jonathan Wareham; Paul Gough; Manuel Damásio; Phill Dickens; Robert Pelton; Marta Sanz-Sole; Salvador Carmona

Appendix:

Assessment Organization

Owner of RAI 2018

Vice President Tuija Pulkkinen, Research and Innovation

Oversight and guidance:

President's Management Team (PMT)

President Ilkka Niemelä, Chair

Provost Kristiina Mälelä

Vice President Antti Ahlava, Campus Development

Vice President Eero Eloranta, Education

Vice President Tuija Pulkkinen, Research and Innovation

Vice President Hannu Seristö, External Relations

Vice President Anna Valtonen, Art and creative practices, also Dean of School of Arts, Design and Architecture

Dean Ingmar Björkman, School of Business

Dean Janne Laine, School of Chemical Technology

Dean Jyri Hämäläinen, School of Electrical Engineering

Dean Gary Marquis, School of Engineering

Dean Jouko Lampinen, School of Science

Chief Financial Officer Marianna Bom

Chief Digital Officer Kati Hagros

Chief Human Resources Officer Riitta Silvennoinen

Director Sirkku Linna, Development

Director Jaakko Salavuo, Communications

Director Teppo Heiskanen, Advancement and Corporate Engagement

Steering group:

Research and Innovation Steering Group (RISG)

Vice President Tuija Pulkkinen, Chair

Vice Dean Ossi Naukkarinen, School of Arts, Design and Architecture

Vice Dean Timo Saarinen / Matti Pohjola, School of Business

Vice Dean Sirkka-Liisa Jämsä-Jounela, School of Chemical Technology

Vice Dean Vesa Välimäki, School of Electrical Engineering

Vice Dean Olli Varis / Pentti Kujala, School of Engineering

Vice Dean Esko Kauppinen, School of Science

Professor Kari Laasonen, Representative of the Professors' Council

Pascale Blyth, Representative of the Student Union

Implementation: RAI office

RAI 2018 Project Managers Marjo Kettunen and Krisztina Cziner

Head of Research Strategic Support Ella Bingham

Academic Coordinator Heidi Henrickson

Head of Open Science and ACRIS Services Anne Sunikka

Leadership Support Services: Information Specialists Leena Huiku,

Anna-Kaisa Hyrkkänen, and Indrek Lõo, Senior Specialist Janne Jämsen,

Development Manager Irma Pasanen, System Specialist Tuija Sonkkila

Advisor Pia Sivenius, School of Arts, Design and Architecture

Development Manager Pekka Saarela, School of Arts, Design and Architecture

Development Manager Tuija Nikko, School of Business

Development Manager Raili Pönni, School of Chemical Technology

Development Manager Sakari Heikkilä, School of Electrical Engineering

Development Manager Soile Koukkari, School of Engineering

Development Manager Marja Niemi, School of Science

Assistants Saara Halmetoja, Hanna Haviola and Jenni Lehtonen

Field Leaders, Field Coordinators, and Student Guides

1: Arts, design and architecture

Dean Anna Valtonen, Field Leader

Iina Ekholm, Field Coordinator

Olivia Hakala, Student Guide

5: Energy

Sanna Syri, Field Leader

Anne Kosola, Field Coordinator

Susanna Tamminen, Student Guide

2: Business and economics

Dean Ingmar Björkman, Field Leader

Tuija Nikko, Field Coordinator

Lauri Ganszaug, Student Guide

6: Health and wellbeing

Paul Lillrank, Field Leader

Markus Mäkelä, Field Coordinator

Ilona Rahnasto, Student Guide

3a: Chemical eng. and physics

Dean Janne Laine, Field Leader

Marjo Kettunen, Field Coordinator

Susanna Tamminen, Student Guide

7: Living environments

Marketta Kyttä, Field Leader

Aija Staffans, Field Coordinator

Olivia Hakala, Student Guide

3b: Engineering

Dean Gary Marquis, Field Leader

Sakari Heikkilä, Field Coordinator

Elias Nordman, Student Guide

8: Innovation ecosystem

Dean Jyri Hämäläinen, Field Leader

Mari Pietikäinen, Field Coordinator

Lauri Ganszaug, Student Guide

4: ICT and mathematics

Dean Jouko Lampinen, Field Leader

Marja Niemi, Field Coordinator

Ilona Rahnasto, Student Guide

RAI 2018

**Research, Art and
Impact Assessment**

Aalto University



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