Aija Ryyppö, Pertti Tikkanen and Pirjo Taskinen (eds.)

Research Assessment Exercise 2020 Report

International Evaluation of Research at the University of Oulu
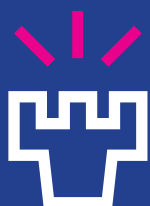
UNIVERSITY OF OULU

Aija Ryyppö, Pertti Tikkanen and Pirjo Taskinen (eds.)

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RAE2020

RESEARCH ASSESSMENT EXERCISE 2020

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Foreword – Greetings from the Vice Rector

It is a great pleasure to welcome the completion of the Research Assessment Exercise (RAE) 2020 of the University of Oulu (UOULU). An overview of the research activities at the level of the entire university is a highly important endeavour pursued at regular intervals. A structural change took place at our university in 2016 when 57 research units (RUs) were formed, 54 of these within the eight faculties and one in each of the three regional units of the university. Hence, this report provides an assessment of the research activities as well as the functionalities of these new unit structures. Importantly, the units' own critical self-evaluation as well as their plans for the coming years combined with external feedback by three evaluation panels can be expected to help the research units in their plans for the future.

In its 2020-2030 strategy UOULU seeks to make significant contributions to solve global challenges in five focus areas: Digitalization and smart society; Understanding humans in change; Changing climate and northern environment; Sustainable materials and systems; and Lifelong health. In defining the focus areas, UOULU considered its overall RAE in 2013-2014, designed to identify world-class research as well as new openings, and various further analysis of its strengths and societal impact. Moreover, as part of a national profiling programme organized by the Academy of Finland, UOULU has identified during 2016-2020 nine profiling areas as spearhead themes that stem from the focus areas. It is foreseeable that the present RAE2020 report will similarly provide valuable input to re-evaluation and updating of UOULU's strategy in the coming years.

The international external evaluators found that the RUs were well aligned with the UOULU focus areas and profiling themes. In their summary the evaluators also noted that the five defined UOULU focus areas give the university a unique profile and that these focus areas are directly related to the sustainability and development goals (SDGs) of the United Nations. Importantly, RAE2020 provides a coherent view for the first time on how our research work within each RU aligns with the global SDGs. UOULU's strategic vision to target its expertise to build a more sustainable, intelligent and humane world is well justified based on the new data.

I wish to warmly thank all involved in generating the RAE2020 results, including our highly esteemed international external evaluators that worked as three field-specific panels under the guidance of their outstanding chairs, the internal RAE working group and especially the highly dedicated experts in quality issues, Dr. Aija Ryyppö and her colleagues, as well as our library's bibliometric team and especially Mr. Jani Sassali. It is important to also acknowledge the Centre for Science and Technology Studies (CTWS) from Leiden University for their knowledgeable analysis of publication data. Strong support for the RAE2020 process was also provided by Rector Jouko Niinimäki, the Management Group of Research and the Research Council. Most importantly, I wish to thank all our personnel at the 57 RUs for their dedication and perseverance throughout the assessment process, despite it being markedly influenced by the Covid-19 pandemic. It is their hard work that makes UOULU "tick" and provides the excellent results that are outlined in the RAE2020 report by the external evaluators.

Taina Pihlajaniemi, Vice Rector (research) 2.11.2021

Executive summary

At the University of Oulu (UOULU) we work as part of the international science community to produce new scientific information and science-based solutions. We also train future pioneers to build a more sustainable, intelligent and humane world. We are committed to promoting the UN's goals of sustainable development with our research and education. UOULU was founded in 1958. Today, with 3400 employees and 13500 students in eight faculties, it is one of the largest and the most multidisciplinary universities in Finland, encompassing fields of a classical university as well as technology and economics and business (**Fig. 1.1**.).

The Universities Act (Section 87. Evaluation (Amendment 1302/2013)) stipulates that universities must evaluate their research activities. According to the decision of the UOULU Board of Directors, a university-level assessment of research (Research Assessment Exercise—RAE) should be performed every sixth year. The RAE is implemented as an international scientific peer review where field-specific scientific panels assess the actual and future impact of the research. The previous RAE evaluations were carried out in 2006 – 2007 and 2012 – 2014 (RAE2013). This RAE2020 evaluation has taken place in 2019 – 2021.

The purpose of RAE2020 is to reveal and confirm the quality and impact of research, confirm the functional structures of research units (RUs) for scientific research, assist in recognizing future research prospects and support scientific renewal at UOULU. Thus, RAE2020 will provide information that can be used to enhance the quality of research and support long-term strategic decision-making at the unit, faculty and university levels. While the assessment will give vital input to the strategy process at the University and Faculty levels, we especially point to the opportunity which the RAE2020 offers for the RUs to plan how to achieve excellence in their fields of research and stimulate the multidisciplinary research approaches for building their excellence.

The planning, preparation, and implementation of RAE2020 was done by the RAE2020 office, guided by a working group appointed by the Rector on February 28th, 2019. The Working Group was guided by the Rectorate, the Executive Committee, the Management Group of Research, and the Research Council. The scientific evaluation was carried out by three discipline-specific external panels consisting of 9 - 13 members (Biosciences, Health and the Environment, BHE; Culture and Society, CS; Natural Sciences and Engineering, NSE).

The RAE2020 assessment was targeted to evaluate all RUs at the eight faculties of UOULU as well as its three regional units, the Sodankylä Geophysical Observatory, the Kajaani University Consortium and the Kerttu Saalasti Institute—in total, 57 RUs. For the RAE2020 evaluation, each RU prepared a self-evaluation report that included two parts: a critical self-evaluation (time scale 2013–June 2020) and a scientific action plan for the next five years.

Moreover, bibliometric analyses were produced for each RU which utilized the results in their own self-assessment. These bibliometric analyses of the RUs were part of the panellists' assessment material. The publication data was based on the "Oulun yliopisto tutkii" publication database for the 2013-2017 period. The analyses were produced in two parts: by the Centre for Science and Technology Studies (CTWS) from Leiden University and by the Oulu University Library. CWTS's research performance analysis covered 57 percent of all publications produced by UOULU, as the analysis was limited to journal articles and conference papers indexed in the Web of Science database. As the analysis performed by CWTS did not fully cover some disciplines at UOULU, the analysis performed by Oulu University Library supplemented the coverage of bibliometrics.

The COVID-19 pandemic had a large influence on the execution of the assessment process. Originally, the evaluation panels were scheduled to visit UOULU to meet with university staff and students, to interview the RUs and hold meetings of the panels to discuss and decide the evaluation results. However, because of the pandemic the panels worked remotely, and the panels' interviews of the RUs were organised as remote Zoom meetings. Thanks to our evaluators' outstanding experience and the resilience of our RUs and supporting staff, the change of mode took place extremely well.

Across the scientific fields of BHE, CS and NSE the specific assessments of the 57 RUs provide detailed external views on their activities and plans. These assessments provide excellent feedback on the current situation and have pointed to development areas and recommended actions.

Altogether, the RAE2020 has been a major effort, and besides the university and RU level analyses, we now have for the first time a coherent view of how the RUs are related to the university´s focus areas and profiling themes (Section 2). Importantly, we also asked the RUs to indicate how their scientific action plans relate to the United Nations Sustainable Development Goals (UN SDGs, Section 2). This assessment shows that the UOULU RUs target all 17 SDGs, the highest contributions being to the goals on 3) Good health and wellbeing, 4) Quality education, 9) Industry, innovation and infrastructure, and 13) Climate action.

The detailed assessment results, evaluations of each RU, each panel's conclusions and university-level conclusions, are presented in Section 4 and Attachments 1-3. Some of the findings are outlined below:

University-level summary and conclusions

In a joint university-level summary and conclusions (Section 5) by the three panels it is noted that the RUs of the UOULU engage actively in research and achieve extremely high standards, with several being world leading. The size of the RUs varies considerably, ranging from powerful multidisciplinary research groups to small groups centred around one top researcher. Managing the RUs is a dynamic process which has to be monitored continuously. Key issues are continuity following retirement of key researchers; subcritical sizes; and non-interacting groups within RUs. Proactive management is required to address each of these issues to ensure the continuity of research.

This summary also notes that the defined five focus areas of UOULU give the university a unique profile. These focus areas are directly related to the UN SDGs. The RUs are aligned very well with these focus areas and use them for developing ambitious, yet feasible strategic plans. The cross-sectional focus area "Changing climate and Northern environment" benefits from contributions of the RUs of all panels, whereas the others are more panel specific. Moreover, societal impact is an important aspect of which all RUs are aware with special efforts directed towards regional benefits.

It is also pointed out that, across the university, there are an enormous range of research disciplines and research is not always measurable within a one-size fits-all approach.

Main points from the summary of the panel Biosciences, Health and the Environment (BHE)

The panel summary on BHE (see 4.1.2.) indicates that the 15 RUs that constitute BHE engage with a number of the strategic focus areas of the University, particularly "Lifelong Health", which is a major focus throughout BHE. There is some research that matches the "Changing Climate and Northern Environment" focus area, however this is less extensive.

The size of the BHE RUs varies enormously with some consisting of only a few principal scientists, whilst others are very large. In all cases, there is a focus on research, and in general all RUs produce research outputs in high-level international journals. The panel scores indicate that the research of the BHE RUs is very high quality. One RU was graded 6, nine were graded 5 (on a scale of 6–1, 6 representing outstanding and 5 excellent levels). Moreover, the research units take part in outreach initiatives and industrial engagement and the panel was impressed by those RUs that were able to successfully engage in this way.

In terms of being forward looking, most BHE RUs had clear plans that aligned with the focus areas of UOULU. In some RUs, owing to the career stage profile of the staff, succession planning should be part of the forward-looking strategy.

Main points from the summary of the panel Culture and Society (CS)

The CS panel (see 4.2.2) notes that a variety of units engage with research on important topics in humanities and the social sciences, and they often do so on multidisciplinary grounds. Overall, the research conducted within the RUs of CS was found to be excellent, empirically and theoretically, and align both with the University's strategic goals and with the UN SDGs.

CS RUs have strong research leadership and a sound academic culture which is supportive of the investigative spirit and conducive to collaboration. There have been many successful research funding bids, especially through Academy of Finland applications. The produced research has a truly broad range of influence and increasingly gains ever wider national and local audiences. The scientific impact is multidimensional and impressive in a substantial rather than strictly or exclusively measurable sense. Among the 12 RUs in the CS area, five were graded 6, and likewise five were graded 5.

As for future development, overall, the CS RUs were found to contain ambitious, yet also realistic and feasible scientific action plans, the proposed research of which promises, if successful, to produce significant new outcomes and further to strengthen the RUs' national, regional and international standing and intervention.

Main points from the summary of the panel Natural Sciences and Engineering (NSE)

The panel for NSE (see 4.3.2) covered the largest number (30) of RUs with research areas ranging from pure mathematics to civil engineering and architecture. The size of the RUs varies from rather small ones to large multidisciplinary groups. The panel found, in general, an excellent match between the research areas of the RUs in NSE and the focus areas of UOULU, in particular in the case of "Sustainable materials and systems", "Digitalization and smart society" and "Changing climate and northern environment". According to the NSE panel, UOULU is developing a unique profile in these areas which sets them apart from other research units both on a national and an international level.

In general, the success rate of the NSE RUs in competitive programmes was found to be very good with a substantial number of both Academy of Finland projects and approved Horizon 2020 proposals. Overall, the scientific level of the research conducted by the panel RUs was found to have a high impact and meet top standards, which is reflected by the fact that four RUs were graded with straight 6/6 by the evaluation panel, and that the average grade approached 5/6. Among the 30 RUs in the NSE area, seven received an overall grade of 6, and 15 were graded 5.

Plans for the strategic development of the NSE RUs were judged to have been developed on the basis of a sound assessment of the current state in almost all cases. Strategic development "at work" can be observed by the continuous realignment of the research areas with the focus areas, particularly in the area of sustainability, which is about to open new and exciting research fields.

Bibliometrics

With respect to **bibliometric analyses**, in the period 2013-2017, almost 15000 publications were published at UOULU and the annual number of publications increased during the period. Peer-reviewed scientific publications accounted for more than 80 percent of all publications. Moreover, 12 percent of the publications were aimed at professional communities and the general public.

According to the performance indicators used in the bibliometric analysis, UOULU performed more than **20 percent above the world average**. The results highlighted the importance of collaboration, with 82 percent of the publications including collaboration with other organizations, while international collaboration accounted for 56 percent of all publications included in the CWTS analysis. International collaboration was also more impactful, as performance indicators for publications with international cooperation showed performance 40-50% above the world average.

1. University of Oulu in brief

UOULU is an international science university which creates new knowledge, well-being, and innovations for the future through high-level research and education. UOULU was founded in 1958 and is one of the biggest and in terms of its disciplinary spectrum one of the broadest universities in Finland (**Fig. 1.1**.). Our strategic goals are to produce new scientific information and science-based solutions, and train future pioneers to build a more sustainable, more intelligent, and more humane world. The research done at UOULU benfits people living at all latitudes, but as one of the northernmost international science universities, we have a particular responsibility towards questions related to the Arctic. UOULU's high-quality research and education have been the basis for the most significant research and innovation hub of the furthest reaches of Northern Europe. With its new strategy from 2020 towards 2030 OULU strives for excellence in science, high societal impact and attractiveness. To realise our ambitious goals, we have built a distinctive scientific profile, reflecting our strongest research and potential for new openings.

#unioulu #arcticattitude

Multidisciplinary research and education

University of Oulu founded

1958

Natural Sciences and Mathematics	Biosciences	Medicine and Health	Economics and Business Administration
Engineering and Architecture	Information and Communication Technologies	Education	Humanities
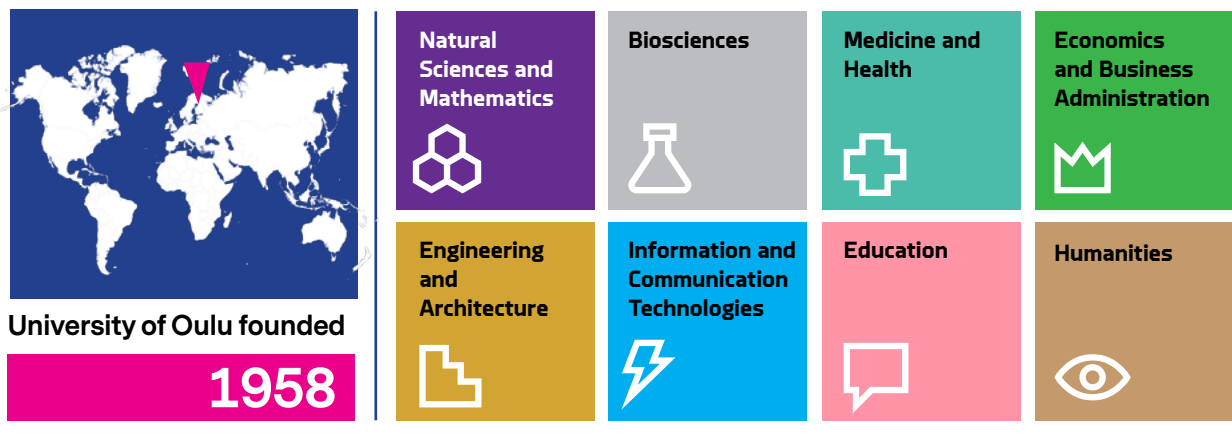
60 000+
Alumni

13 500
Students

3 400
Staff

Fig.1.1. Overview and the disciplines at UOULU. The disciplinary spectrum supports multidisciplinary approaches in research and education.

Principles that guide our activities are crystallized in the values of the university community: creating new, taking responsibility, and succeeding together. UOULU is committed to acting responsibly towards society and the environment, to seek solutions for the sustainable use of the earth's resources, and to make ecologically responsible choices in its own operations by advancing sustainable development via research, education, societal interaction, and campus development.

North changes the world – More sustainable, more intelligent, more humane

STRATEGY OF UNIVERSITY OF OULU 2020–

Creating new

Taking responsibility

Succeeding together
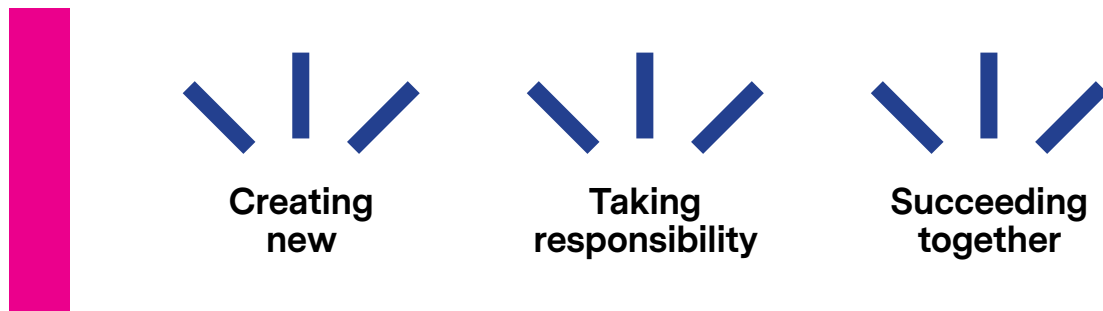
UOULU operates with a budget of about 250 million € and it produces close to 3000 degrees and scientific publications annually (numbers for 2020 in **Fig. 1.2.**). According to the latest international university assessments, UOULU is among the 251-300 best (3rd in Finland) in the Times Higher Education (THE) university ranking, among the 401-500 best (4th in Finland) in the Shanghai Ranking, at position #446 (5th in Finland) in the Center for World University Ranking (CWUR), and at position #377 (5th in Finland) in the QS University Rankings. Importantly, the key figures of UOULU's competitive research funding and research itself have all been on an upward trajectory for the past several years.

The university is a strong producer of research-based innovations and spin-off companies (**Fig. 1.2**), and it is at the heart of the regional R&D ecosystem. The Oulu region is a highly international and strong innovation centre. Its R&D investments per capita are the highest in Finland, and the total investments are the 2nd highest following the capital region. The region has a remarkably robust profile in electronics and ICT, including ~650 companies. Today, the Oulu region is one of the world's major players in wireless communications technology development and applications, with the aim to penetrate all areas of life in the future. UOULU has a central role in the region's hi-tech R&D activities, which is well recognized in UOULU's 6G Flagship programme, one of the first two flagships appointed by the Academy of Finland (AF) in 2018. Recently, innovations in health and well-being, biotechnology and the bioeconomy with direct links to UOULU have grown rapidly and gained significance. Moreover, the region also has strong industries in metal, energy and resource efficiency supported by UOULU's expertise.

Key figures

Funding total in 2020 M€
250

Research based spin-off companies since 2000
71

Invention disclosures in 2020
33

Bachelor's degrees in 2020
1 173

Master's degrees in 2020
1 509

Doctor's degrees in 2020
143

International rankings
301–600

top 3%
of the world's universities

2 728
Scientific publications in 2020

2 825
Degrees in 2020
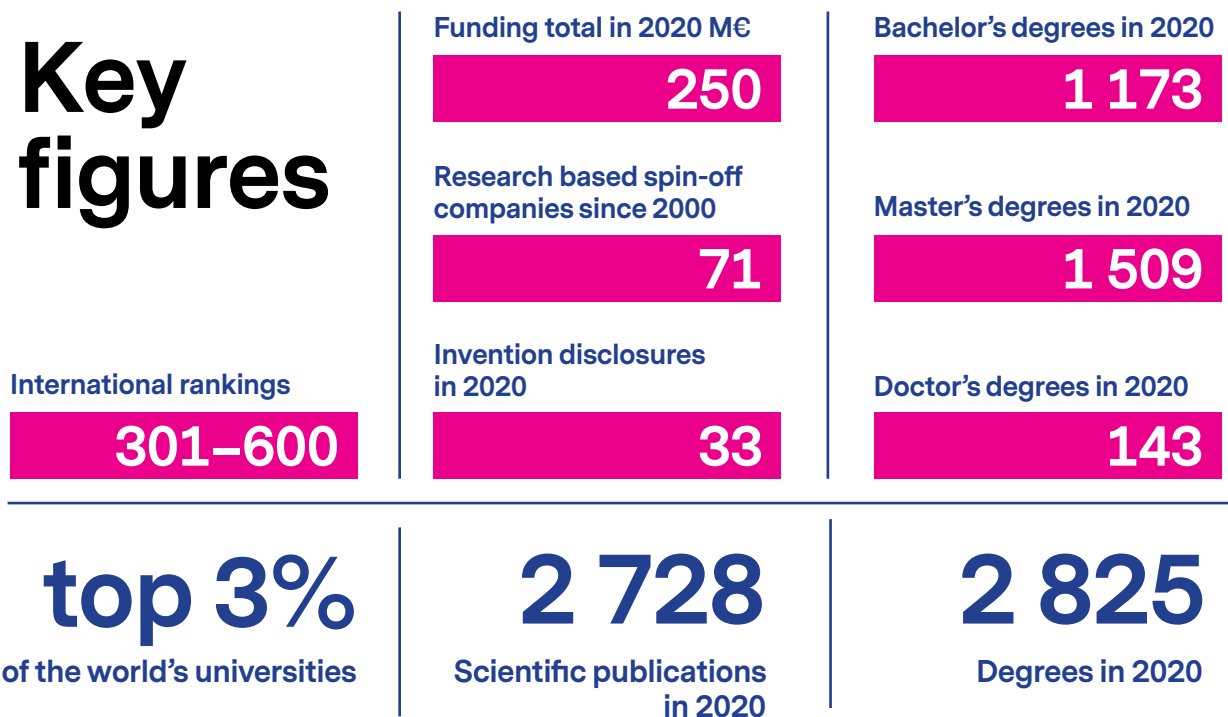
Fig. 1.2. Key figures of UOULU in 2020.

The **eight faculties of UOULU** are Biochemistry and Molecular Medicine (BMM), Education (EDU), Humanities (HUM), Information Technology and Electrical Engineering (ITEE), Medicine (MED), the Oulu Business School (OBS), Science (SCI) and Technology (TECH). In addition to the faculties, UOULU has **three regional units** of research and/or education located in other parts of Finland (**Fig. 1.3.**).

The research units (RU) chosen as targets for the RAE2020 assessment were established in 2016 from traditional departments. Typically larger than traditional departments, RUs are profit-responsible budgetary administrative units consisting of several research groups. The RUs are resourced based on educational needs and research outcomes with the goal to increase outcome accountability through cost awareness, internal entrepreneurship and coherence. In total, there are 54 RUs in the faculties and one in each of the regional units.

University of Oulu

Linnanmaa campus, Oulu

Kontinkangas campus, Oulu

Sodankylä Geophysical Observatory

Oulanka Research Station, Kuusamo

Kajaani University Consortium

Kokkola University Consortium

Kerttu Saalasti Institute, Nivala
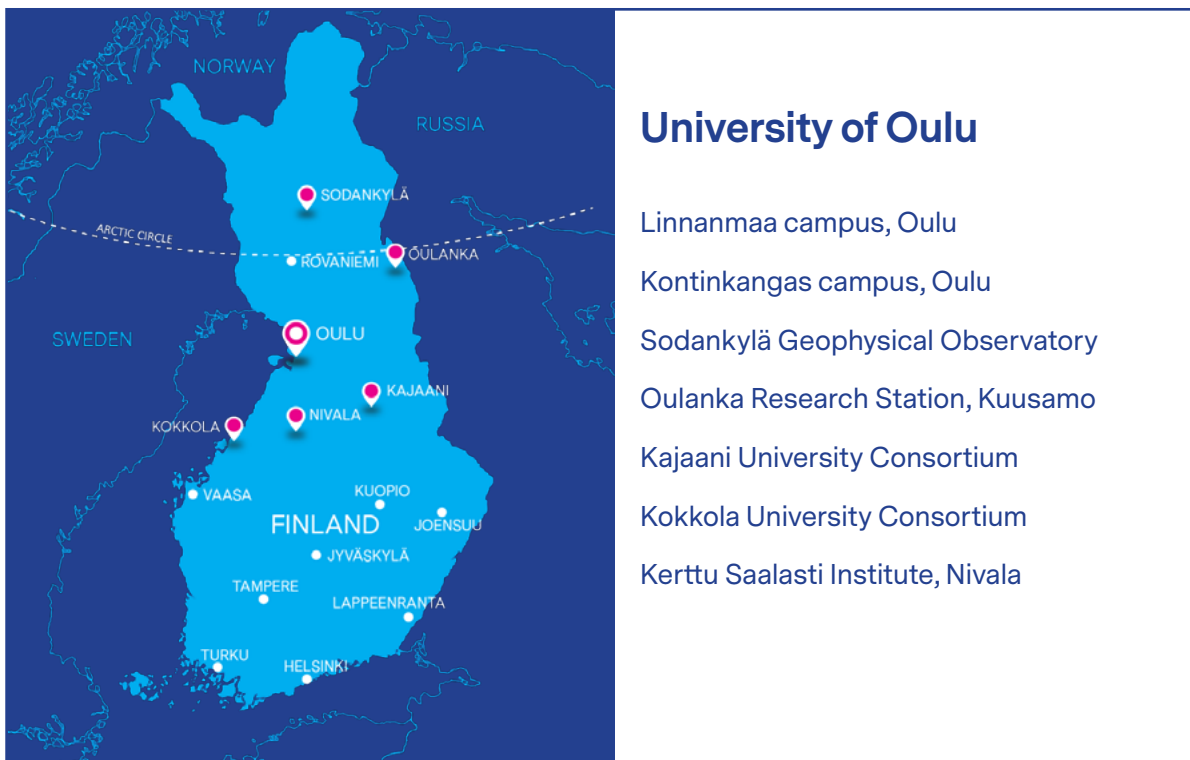
Fig. 1.3. Locations of the UOULU campuses and regional units (red).

HR EXCELLENCE IN RESEARCH

The award of the HRS4R identifies the research institutions and organisations supporting a favorable and boosted work environment

Our **HR policies** and practices highlight openness, transparency and merit and adhere to the Act of Equality between Women and Men. In recruiting new top scientists, we apply international calls and a tenure track process with the possibility of a full professorship, to strengthen our strategic research programmes. The European Commission's Human Resources Strategy for Researchers (HRS4R) is a key tool to help us build on the UOULU vision. UOULU was awarded a renewal of the HR Excellence in Research label in 2020, which was first gained in 2014. In recent years, we have actively and successfully increased the number of researchers with a PhD, both postdoctoral and more senior scientists, in relation to doctoral students (**Fig. 1.4.**).

Fig. 1.4. The number of academic staff (full-time equivalents, FTE) at UOULU in various career stages 2013-2020. Definitions of academic staff and career stages as in Ministry of Education and Culture (MEC) data collection. Career stages typically: I = doctoral students in UOULU payroll, II = postdoctoral researchers, III = senior scientists, incl. assistant professors, IV = professors, incl. associate professors. Data from MEC's portal "Vipunen".

Through international calls and other measures, we are committed to increasing the proportion of international researchers in our academic staff. This strong trend has already taken place for doctoral students and postdoctoral researchers, with target levels set to be 40% for internationals in both career stages by 2024 (**Fig. 1.5.**). UOULU's degree of internationalization amongst the academic staff is among the top four nationally.
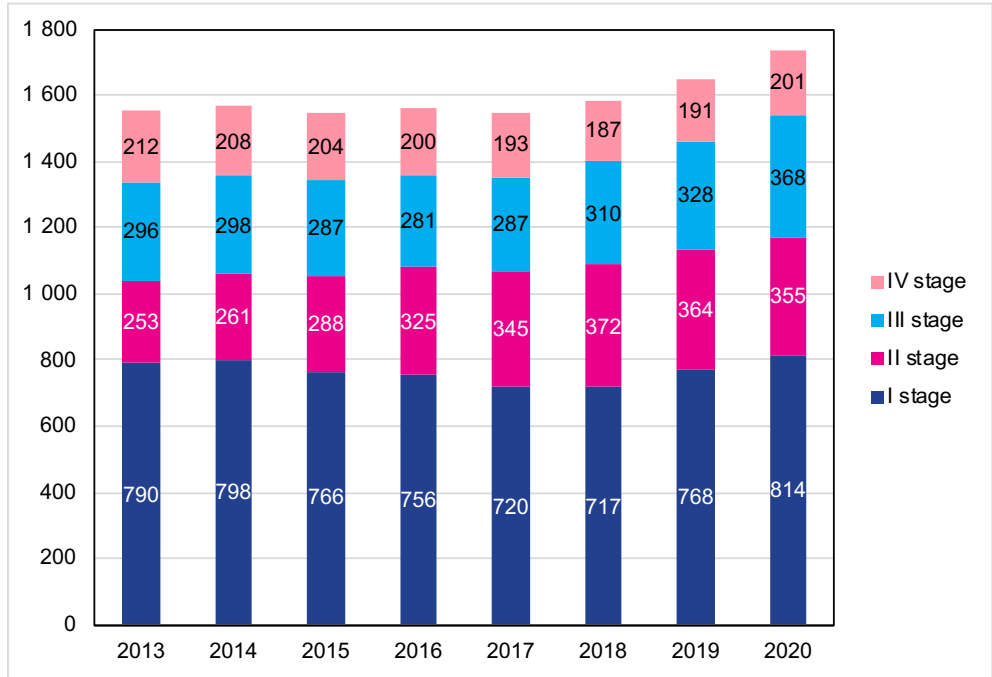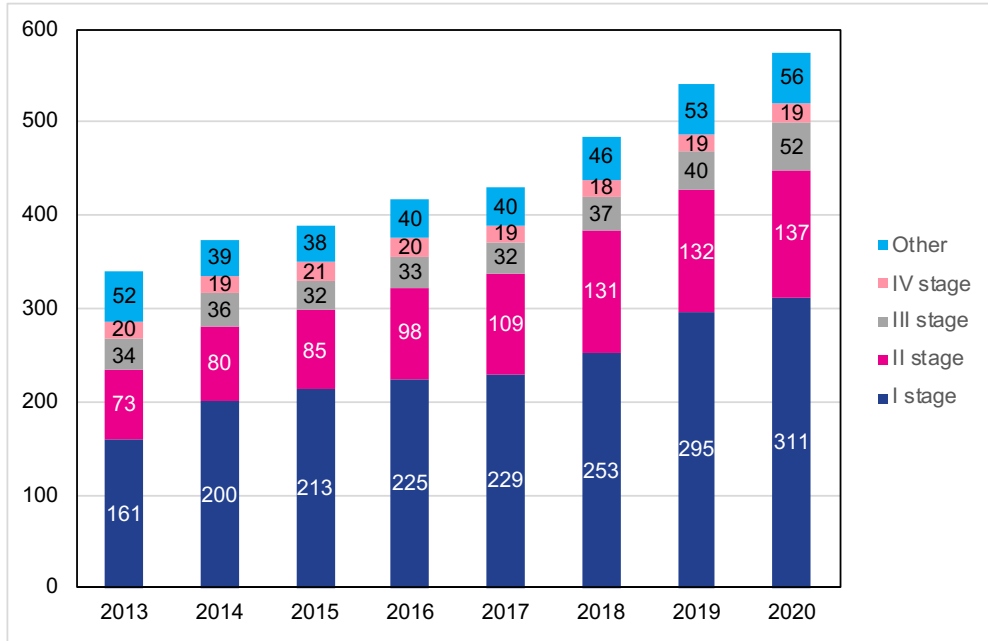
Fig. 1.5. The number of international academic staff (full-time equivalents, FTE) of UOULU in various career stages 2013-2020. Definitions of internationality, academic and other staff, and career stages as in MEC data collection. Career stages typically: I = doctoral students in UOULU payroll, II = postdoctoral researchers, III = senior scientists, incl. assistant professors, IV = professors, incl. associate professors, other = research assisting staff, incl. laboratory technicians. Data from MEC's portal "Vipunen".

Research focus areas and scientific profile. In its new strategy, UOULU has six **strategic developmental programmes**, including the programme of research, **"High-level impactful research"** (**Fig. 1.6**). The UOULU aims to be among the best places in the world to do research in the research profiling areas by strengthening research in emerging fields and multidisciplinary activities, systematically monitoring and developing the quality of research, developing high-quality research infrastructures and promoting responsible research and the utilisation of open research information.

Fig. 1.6. The six strategic developmental UOULU programmes.

In all its activities, UOULU strives for excellent quality, performance and attractiveness. In its 2020-2030 strategy UOULU seeks to make significant contributions to solve global challenges in **five focus areas**: Digitalization and smart society; Understanding humans in change; Changing climate and northern environment; Sustainable materials and systems; and Lifelong health (**Fig. 1.7.**).

Moreover, UOULU has identified world-class research and new multidisciplinary openings that form **nine profiling areas** (**Fig. 1.7.**). This scientific profile has been gradually built through participation in a national research profiling programme in which the Academy of Finland grants competitive funding to Finnish universities to support them in strengthening their research profiles and improving the quality of research. The universities' proposals are evaluated by an international panel of experts, and in the most recent profiling call in 2020, UOULU's proposal was ranked 2nd best among 13 universities.

Fig. 1.7. UOULU strengthens the multidisciplinary profile and improves the quality of research via solving global challenges in five focus areas (white circles) that consist of the nine profiling areas of research (coloured cubes).

The research also includes the development of high-quality **research infrastructures** and their compilation into quality services. UOULU has established six university-level research infrastructures that provide high-level services in a wide range of disciplinary fields based on open access principles. In addition, many infrastructures operate at RU and faculty level. Moreover, UOULU coordinates five infrastructures on Finland's research infrastructure roadmap and is responsible for coordinating four European infrastructures in Finland.

Four **focus institutes** promote multidisciplinary research cooperation, planning of thematic activities and doctoral training that crosses faculty boundaries in UOULU´s multidisciplinary focus and profiling areas: the Kvantum Institute in the focus areas of "Sustainable materials and systems" and "Changing climate and northern environment"; the Biocenter Oulu (BCO) in "Lifelong health"; the Eudaimonia Institute in "Understanding humans in change"; and Infotech Oulu in "Digitalization and smart society" (**Fig. 1.8**.). Arctic research and cooperation are coordinated by the Thule Institute. The institutes promote interdisciplinary networking of research groups as well as co-operation with national and international partners.

External peer evaluation of the research in all focus areas is performed on a rolling 4-year basis through open calls for **strategic research projects** and assessment by international evaluation panels. In 2020 we selected 15 strategic Kvantum-affiliated projects for 2021-2024 based on an open call that received 41 applications. At present, we have 52 strategic projects coordinated by the focus institutes, while the research itself takes place in the faculties and regional units. Importantly, all strategic projects support UOULU's profiling areas. An entirely new programme was devised in 2017, namely a call for emerging projects of young scientists aspiring to become group leaders. Nineteen 4-year **emerging projects** were

selected for 2018-2022. Altogether, through a dynamic and open process we have built a strategic project portfolio consisting of top projects (world-class research and new openings) in all focus areas and their profiling areas, supported by significant target strategic funding (52 post-doc positions and 90 4-year PhD positions).

BIOCENTER OULU	**LIFELONG HEALTH**	Digitalized solutions for future heathcare
		Fibrosis in chronic diseases and cancer
EUDAIMONIA INSTITUTE	**UNDERSTANDING HUMANS IN CHANGE**	Strengthening human capabilities in the digital era
INFOTECH INSTITUTE	**DIGITALIZATION AND SMART SOCIETY**	6G solutions for data-driven society
		Dynamic data modelling
KVANTUM INSTITUTE	**CHANGING CLIMATE AND NORTHERN ENVIRONMENT**	Changing space environment
		Arctic interactions and global change
	SUSTAINABLE MATERIALS AND SYSTEMS	Physics for sustainable steel
		Inorganic side streams

Fig. 1.8. The four focus institutes, five focus areas and nine profile fields of research at UOULU. The profiling areas stem from the focus areas indicated by the colours.

2. Assessment goals, methods and process

2.1. Assessment goals

The purpose of RAE2020 is to reveal and confirm the quality and impact of research, confirm the functional structures of research units for scientific research, assist in recognizing future research prospects and support scientific renewal at UOULU. Thus, the RAE2020 assessment will provide information that can be used to enhance the quality of research and support long-term strategic decision-making at the unit, faculty and university levels. While the assessment will provide vital input to the strategy process at the university and faculty levels, we especially point to the opportunity which the RAE2020 offers for the research units to plan how to achieve excellence in their fields of research and stimulate the multidisciplinary research approaches for building their excellence.

The eight faculties vary in size, and the number of RUs and academic staff per faculty also varies (**Table 2.1.1.**). The evaluation units of this RAE2020 were 54 RUs of faculties and three regional units: the **Kerttu Saalasti Institute** (Micro-entrepreneurship, Future manufacturing technologies and Regional excellence), **Kajaani University Consortium** (Measurement technology of cleantech and Health & wellbeing) and **Sodankylä Geophysical Observatory**. All RUs participated in the evaluation; the total number of evaluated units amounted to 57 (**Table 2.1.1.**). In 2019 there were 2078 academic staff at these units, which constituted 80% of UOULU's total staff (**Table 2.1.1.**).

Table 2.1.1. The number of research units and academic staff (in 2019) of the faculties and regional units evaluated in RAE2020. Academic staff here as in MEC's data collection, consisting of doctoral students on the UOULU payroll, postdoctoral researchers, senior scientists (including assistant professors) and professors (including associate professors).

Faculty / Regional unit	Number of Research Units	Number of Academic Staff
Biochemistry and Molecular Medicine (BMM)	3	141
Education (EDU)	3	146
Humanities (HUM)	4	177
Information Technology and Electrical Engineering (ITEE)	12	436
Medicine (MED)	11	376
Oulu Business School (OBS)	3	94
Science (SCI)	6	257
Technology (TECH)	12	371
Kajaani University Consortium (KUC)	1	19
Kerttu Saalasti Institute (KSI)	1	42
Sodankylä Geophysical Observatory (SGO)	1	19
In total:	**57**	**2 078 (80% of total staff)**

RAE2020 aimed to identify the following aspects at different levels:

University level:

- research quality, strengths, areas for improvement and critical mass formation
- internal, national and international links
- scientific and societal impact of research
- new openings

Focus area level:

- content, quality and scope of focus areas
- overall view of each focus area's activity, multidisciplinarity, overlaps and blind spots

Faculty level:

- research quality, strengths, and areas for improvement
- relevance and the functionality of the research unit structure for research—whether a critical mass has been achieved to establish internal, national and international significance
- scientific and societal impact of research
- new openings

RU level:

- current strengths and development needs, structure of RUs, achievements and future plans from a research perspective
- connection to the research focus areas of the UOULU
- position in the field of scientific profiling at the UOULU
- co-operation within the unit and between units and within or between profiling areas
- whether a critical mass of RU staff has been achieved and whether the researcher structure allows the continuity of the unit
- research environment and use of research infrastructures
- national and international networking
- future plans
- doctoral training and career paths

In addition, the RUs were analyzed in relation to the renewed strategy of the faculties, focus institutes and the University. Results and recommendations of the RAE2020 assessment and the material collected during the assessment process will positively enhance the vital input to the rolling strategy process of UOULU.

2.2. Main phases of the RAE2020 process for the research units (from the RUs' point of view)

Summary of RUs

The data provided by each RU included their full name and an abbreviation, the number of academic staff (in 2019), and the focus area most relevant for them (**Tables 2.2.1**, **2.2.2.** and **2.2.3**.). This formed the basis for assigning each RU to one of the three evaluation panels. Some RUs were also evaluated in a secondary panel.

Table 2.2.1. RUs evaluated by the Biosciences, Health and the Environment (BHE) Panel. The BHE Panel evaluated RUs NSE 02 and NSE 30 as the secondary evaluation panel.

RAE2020 code	Short name of the Research Unit	Name of the Research Unit	Academic staff in 2019	Faculty	Focus area	First and secondary panel, if RU has registered two panels
PANEL BIOSCIENCES, HEALTH AND THE ENVIRONMENT						
BHE 01	Biomedicine	Research Unit of Biomedicine	36	MED	Lifelong Health	
BHE 02	Cancer-TransMed	Cancer Research and Translational Medicine Research Unit	36	MED	Lifelong Health	
BHE 03	CERH	Center for Environmental and Respiratory Health Research	15	MED	Lifelong Health	
BHE 04	DisNetworks	Disease Networks	44	BMM	Lifelong Health	
BHE 05	ECMH	ECM and Hypoxia	44	BMM	Lifelong Health	
BHE 06	EcoGen	Ecology and Genetics	82	SCI	Changing climate and northern environment	
BHE 07	ELITE	ELITE	53	MED	Lifelong Health	
BHE 08	InternalMed	Research Unit of Internal Medicine	22	MED	Lifelong Health	
BHE 09	MIPT	Research Unit of Medical Imaging, Physics and Technology	67	MED	Lifelong Health	
BHE 10	Neuro	Research Unit of Clinical Neuroscience	17	MED	Lifelong Health	
BHE 11	Nursing	Research Unit of Nursing Science and Health Management	18	MED	Lifelong Health	
BHE 12	OralHealth	Research Unit of Oral Health Sciences	43	MED	Lifelong Health	
BHE 13	PEDEGO	PEDEGO Research Unit	54	MED	Lifelong Health	
BHE 14	PSB	Protein and Structural Biology	53	BMM	Lifelong Health	
BHE 15	Surgery	Research Unit of Surgery, Anesthesia and Intensive Care	15	MED	Lifelong Health	
NSE 02	BISG	Biomimetics and Intelligent Systems	30	ITEE	Digitalization and smart society	NSE 1, BHE 2
NSE 30	WE3	Water, Energy and Environmental Engineering	47	TECH	Changing climate and northern environment	NSE 1, BHE 2
RUs in total 17			**676**	**5**	**3**	

Table 2.2.2. RUs evaluated by the Culture and Society (CS) Panel. The CS Panel evaluated RUs BHE 11, NSE 10 and NSE 24 as the secondary evaluation panel.

RAE2020 code	Short name of the Research Unit	Name of the Research Unit	Academic staff in 2019	Faculty	Focus area	First and secondary panel, if RU has registered two panels
PANEL CULTURE AND SOCIETY						
CS 01	EAF	Department of Economics, Accounting and Finance	35	OBS	Understanding humans in change	
CS 02	Geography	Geography Research Unit	42	SCI	Understanding humans in change	
CS 03	Giellagas	Giellagas Institute	14	HUM	Understanding humans in change	
CS 04	HistCultComm	History, Culture and Communication Studies	81	HUM	Understanding humans in change	
CS 05	KSI	Kerttu Saalasti Institute	42	Regional	Understanding humans in change	
CS 06	LangLit	Languages and Literature	63	HUM	Understanding humans in change	
CS 07	LLP	Learning and Learning Processes	45	EDU	Understanding humans in change	
CS 08	Logo	Logopedics	19	HUM	Understanding humans in change	
CS 09	MAI	Martti Ahtisaari Institute	13	OBS	Understanding humans in change	
CS 10	MMI	Department of Marketing, Management and International Business	46	OBS	Understanding humans in change	
CS 11	TTEC	Teachers, Teaching and Educational Communities	65	EDU	Understanding humans in change	
CS 12	VISE	Values, Ideologies and Social Contexts of Education	36	EDU	Understanding humans in change	
BHE 11	Nursing	Research Unit of Nursing Science and Health Management	18	MED	Understanding humans in change	BHE 1, CS 2
NSE 10	IEM	Industrial Engineering and Management	26	TECH	Sustainable materials and systems	NSE 1, CS 2
NSE 24	OSA	Oulu School of Architecture	20	TECH	Sustainable materials and systems	NSE 1, CS 2
RUs in total 15			**565**	**6 + 1 regional unit**	**2**	

Table 2.2.3. RUs evaluated by the Natural Sciences and Engineering (NSE) Panel. The NSE Panel evaluated RUs CS 02, CS05 and CS 09 as the secondary evaluation panel.

RAE2020 code	Short name of the Research Unit	Name of the Research Unit	Academic staff in 2019	Faculty	Focus area	First and secondary panel, if RU has registered two panels
PANEL NATURAL SCIENCES AND ENGINEERING						
NSE 01	ACM	Applied and Computational Mathematics	9	ITEE	Digitalization and smart society	
NSE 02	BISG	Biomimetics and Intelligent Systems	30	ITEE	Digitalization and smart society	
NSE 03	CAS	Circuits and Systems	28	ITEE	Digitalization and smart society	
NSE 04	CMVS	Center for Machine Vision and Signal Analysis	56	ITEE	Digitalization and smart society	
NSE 05	CPE	Chemical Process Engineering	15	TECH	Sustainable materials and systems	
NSE 06	CWC-NS	CWC – Networks and Systems	56	ITEE	Digitalization and smart society	
NSE 07	CWC-RT	CWC – Radio Technologies	90	ITEE	Digitalization and smart society	
NSE 08	ECE	Environmental and Chemical Engineering	44	TECH	Sustainable materials and systems	
NSE 09	FPE	Fibre and Particle Engineering	58	TECH	Sustainable materials and systems	
NSE 10	IEM	Industrial Engineering and Management	26	TECH	Sustainable materials and systems	
NSE 11	IMS	Intelligent Machines and Systems	12	TECH	Sustainable materials and systems	
NSE 12	INTERACT	Human Coputer Interaction and Human-Centered Development	17	ITEE	Digitalization and smart society	
NSE 13	KUC	Kajaani University Consortium	19	Regional	Digitalization and smart society	
NSE 14	M3S	Empirical Software Engineering in Software, Systems and Services	46	ITEE	Digitalization and smart society	
NSE 15	MathSci	Mathematic Sciences	35	SCI	Sustainable materials and systems	
NSE 16	Met	Process Metallurgy	25	TECH	Sustainable materials and systems	
NSE 17	MIC	Microelectronics	31	ITEE	Digitalization and smart society	
NSE 18	MME	Materials and Mechanical Engineering	46	TECH	Sustainable materials and systems	
NSE 19	NANOMO	Nano and Molecular Systems Research Unit	42	SCI	Sustainable materials and systems	
NSE 20	NMR	NMR Research Unit	22	SCI	Sustainable materials and systems	
NSE 21	OASIS	Oulu Advanced Research on Service and Information Systems	11	ITEE	Digitalization and smart society	
NSE 22	OMS	Oulu Mining School	27	TECH	Sustainable materials and systems	
NSE 23	OPEM	Opto-Electronics and Measurement Techniques	23	ITEE	Digitalization and smart society	
NSE 24	OSA	Oulu School of Architecture	20	TECH	Sustainable materials and systems	
NSE 25	SCT	Structures and Construction Technology	19	TECH	Digitalization and smart society	
NSE 26	SGO	Sodankylä Geophysical Observatory	19	Regional	Changing climate and northern environment	
NSE 27	SpaceAstro	Space Physics and Astronomy	34	SCI	Changing climate and northern environment	
NSE 28	SusChem	Sustainable Chemistry	32	TECH	Sustainable materials and systems	
NSE 29	UBICOMP	Center for Ubiquitous Computing	39	ITEE	Digitalization and smart society	
NSE 30	WE3	Water, Energy and Environmental Engineering	47	TECH	Changing climate and northern environment	
CS 02	Geography	Geography Research Unit	42	SCI	Understanding humans in change	CS 1, NSE 2
CS 05	KSI	Kerttu Saalasti Institute	42	Regional	Understanding humans in change	CS 1, NSE 2
CS 09	MAI	Martti Ahtisaari Institute	13	OBS	Understanding humans in change	CS 1, NSE 2
RUs in total 33			**1 075**	**4 + 3 regional units**	**4**	

Pre-registration

The first RAE2020 briefing for the university staff was held on 14.6.2019. The staff were informed of how to fill in the pre-registration form (call open 15.8.–15.10.2019), select the evaluation panel (**Table 2.2.1.–2.2.3.**), check the materials submitted by the administration including personnel lists (check 15.8.–15.9.2019) and publication lists (check 15.8.2019–15.10.2019). The RUs were also asked to suggest panellist candidates.

Critical self-evaluation and scientific action plan

Instructions and a structured self-evaluation form to be filled in by each RU were created by the RAE2020 working group. The form encompassed:

1. The current research performance and research environment including the scientific quality and impact of the research, societal impact of the research and quality of the research environment.

2. Future potential, impact and renewal of the RU based on the future research strategy and impact of the RU for 2020–2025 including the strategic visions and feasibility of the scientific action plan.

The RUs were briefed on how to fill the RAE2020 self-evaluation and scientific action plan on 17.3.2020 remotely, because of the COVID-19 pandemic. The RUs were given three months (17.3–17.6.2020) to prepare this document. The RUs were encouraged to engage academic staff from all research career stages (from doctoral students to professors) to participate.

Each RU was provided with bibliometric analyses carried out by CWTS Leiden and UOULU Library on their publication achievements for 2013–2017 (see 2.4.) for the self-evaluation. To assist in the interpretation of the RU-level publication data, the RUs could arrange a remote meeting with the RAE2020 bibliometrics team members.

Panels' interviews of research units

The panels conducted interviews with the RUs remotely via Zoom. A maximum 5 people (2–4 principal investigators including the RU leader, and a postdoc or a doctoral student) from each research unit participated in the interview. The interviews took place on the following dates:

- Natural Sciences and Engineering (NSE) Panel on Monday 26.4. and Tuesday 27.4.
- Culture and Society panel (CS) Panel on Wednesday 28.4.
- Biosciences, Health and the Environment (BHE) Panel on Thursday 29.4.

Those RUs which also wanted a secondary panel assessment were interviewed only on the day of the primary panel. The RUs could participate from any locality with a well-functioning Internet connection. All interviewees had a webcam, turned on during the interview. The RUs were responsible for a good connection and a webcam themselves.

The time booked for each RU was 40 minutes, including 25 minutes reserved for interviewing the RU. Before the interview, the RUs had 5 minutes to ensure the transition from the ZOOM waiting room to the webinar. After the interview, the panel had a 10-minute internal discussion about the research unit. The interviews were recorded and were available only to panellists for a 1 month. All interviews proceeded as planned, without any technical difficulties and within the pre-set timetable.

2.3. Evaluation performed by the expert panels

Panels

The RAE2020 evaluation of research units was performed by three international panels:

1. Biosciences, Health and the Environment (NSE)
2. Culture and Society (CS)
3. Natural Sciences and Engineering (NSE)

The research fields of the panels were based on the research council division of the Academy of Finland (see chapter 4.).

The RUs were asked to suggest panel candidates in the pre-registration to the RAE2020 evaluation. Any conflict of interest with the subjects of the evaluation was checked in the invitation sent to panellist candidates and with the research units. The material provided for the panels to be used as information sources of the RUs were:

- a self-evaluation and scientific action plan report
- bibliometric analyses done by the UOULU Library and CWTS

In addition, the panels interviewed the RUs via a remote Zoom meeting.

Evaluation criteria and rating scale

The expert panels were requested to assess the RUs and give a numeric evaluation (rating 1-6), and written feedback of the following parts:

1. The current research performance and research environment based on the basic information about the research units (RUs) (section 1 in the self-evaluation report) and reflective analyses of the RUs (section 2 in the self-evaluation report). The evaluation aspects for numerical and written feedback included the scientific quality and impact of the research, the societal impact of the research and the quality of the research environment.

2. The future potential, impact and renewal based on the RU's Scientific Action Plan for 2020–2025 (section 3 in the self-evaluation report).

Rating scale of research units

1. Poor
2. Fair
3. Good
4. Very Good
5. Excellent
6. Outstanding

An RU rating of 6 (outstanding) needed to be exceptional in terms of research quality, yet this rating was considered to be realistic and attainable. The rating was considered in relation to the international level in the fields of the research concerned, not in relation to the other RUs of the University of Oulu.

When needed, an RU was evaluated by a scientific expert to provide additional support to the panel through an external review. More detailed information is available in **in Appendices 1-3**.

An overview of the work by the panels is presented in **Table 2.3.1**.

Table 2.3.1. The RAE2020 panel's tasks and timetable.

Tasks	Timetable
Getting familiar with the panels' workspace containing instructions, RUs' self-evaluations and evaluation forms for panellists.	From late January 2021
Introduction and instruction webinars to the panellists.	From February 2021 up to end of the panels' work, also additional webinars organized for panel Chairs.
If needed, an *RU can be evaluated by an expert outside the panel to provide additional support through an external review*. The panel Chair informs the RAE2020 office (aija.ryyppo@oulu.fi) about the need for external reviewers.	By end of March, 2021
Writing remote private evaluations of the RUs assigned (about 3-5). Panellists fill in a form containing the evaluation criteria, rating scale and guiding questions.	By April 18th, 2021
Participating in panel-specific *interview webinars* of RUs	Week 17 (April 26th–29th, 2021)
Combining the separate private evaluations of the RUs with the other panellists assigned to the RUs (this review is later given only to the RU, the RU's Dean and Rectorate, not published).	By May 23rd, 2021
Writing public evaluations of the RUs with the other panellists assigned to the RUs (this review is used in the RAE2020 publication). Panellists fill in a form with guiding questions.	By June 15th, 2021
Participating in whole-panel discussions and making the final ranking of the RUs (this ranking is used in the RAE2020 publication). The Chair fills in a form containing instructions. If needed, the panellists *update the private and public evaluations of the RUs* based on the final ranking.	By June 30th, 2021
Writing a panel summary report, done by the panel Chair with the support of the other panel members (this report is used in the RAE2020 publication). The Chair fills in a form with guiding questions.	By August 15th, 2021
The panel chairs write *a summary report on UOULU* with the support of the other panel members (this report is used in the RAE2020 publication). The chairs fill in a form with guiding questions.	By August 15th, 2021

Publication of RU-level assessment results

A public description and panel evaluations of the RUs are provided in this report. In addition, each RU also receives a more detailed private evaluation based on panel feedback. The bibliometric analyses are published at the university and faculty level. In view of adhering to best practices in scholarly research evaluation, the bibliometric analyses at the RU level are not published but served as material for the RUs in their self-assessment. The RU-level data is also provided to the Dean of the faculty where the RU operates and to the university's rectorate to support strategic development considerations.

2.4. Bibliometric analyses

In the RAE2020 assessment, bibliometric analyses were performed for each of the 57 RUs. The primary role of the analyses was to provide additional information to the RUs in their own self-assessments. At the same time, the analyses were also part of the panellists' assessment material.

Bibliometric analyses were performed using the publication data of the **Oulun yliopiston tutkii** database for each unit. Since the data collection started in spring 2019, the period covered in the analyses is 2013–2017. The bibliometric analyses were carried out in two parts: The Centre for Science and Technology Studies (hereafter CWTS) unit of the Leiden University carried out a research performance analysis based on the publications contained in the Web of Science database and the UOULU Library carried out its own analyses based on all publications of the RUs.

The bibliometric analyses based on the publications of the RUs were for the use of the units themselves for writing the self-evaluation and scientific action plan, as well as for the panellists. In addition to this, both CWTS and the library also performed separate analyses for the entire university as well as for all eight faculties. These reports are available at http://urn.fi/urn:isbn:9789526231143 (UOULU Library´s report) and http://urn.fi/urn:nbn:fi-fe2021101551288 (CWTS´s report).

The main steps involved in the implementation of bibliometric analyses are presented in **Table 2.4.1**.

Table 2.4.1. Steps and timetable of bibliometric analyses

Steps	Timetable
Preparation of publication data	Summer 2019
Verification of publication data in RUs	Autumn 2019
Preparation of publication data for CWTS	Autumn 2019
Bibliometric analyses of the RU level by CWTS	Winter 2019-2020
Bibliometric analyses of the RU level by UOULU Library	Winter 2019-2020
UOULU Library support for RUs for interpreting the bibliometric analyses	Spring 2020
Bibliometric analyses of the university and faculty level by CWTS	Autumn 2020
Bibliometric analyses of the university and faculty level by UOULU Library	Autumn 2020

2.5. Assessment organization

RAE2020 Working Group

Vice Rector for Research, Taina Pihlajaniemi, Chair
Professor, Tuija Mainela, Oulu Business School, Vice Chair
Quality Manager, Aija Ryyppö, Unit for Strategy and Science Policy, Secretary
Library Director, Minna Abrahamsson-Sipponen, Oulu University Library
Vice Rector for Education, Helka-Liisa Hentilä (28.2.2019–14.7.2020)
Vice Rector for Education, Tapio Koivu (14.7.2020–)
Professor, Henrikki Liimatainen, Faculty of Technology
Head of Planning, Pertti Tikkanen, Unit for Strategy and Science Policy
Doctoral Student, Pauli Väisänen, Faculty of Science

RAE2020 Office

Quality Manager, Aija Ryyppö, Unit for Strategy and Science Policy, RAE2020 Project Manager
Head of Planning, Pertti Tikkanen, Unit for Strategy and Science Policy
Coordinator, Pirjo Taskinen, Unit for Strategy and Science Policy (1.1.–31.12.2020)

RAE2020 bibliometric team

Library Director, Minna Abrahamsson-Sipponen, Oulu University Library
Senior Information Specialist, Raija Heino, Oulu University Library
Senior Information Specialist, Aila Louhelainen, Oulu University Library
Senior Information Specialist, Jani Sassali, Oulu University Library
Senior Information Specialist, Tiina Sipola, Oulu University Library

RAE2020 bibliometrics from Leiden University

Senior Researcher, Deputy Director of CWTS for Projects, Ed Noyons, CWTS Leiden University

3. Assessment results at the university level

Faculties and Regional units by focus areas	BMM		EDU		HUM		OBS		SCI	
RU I No. of academic staff in 2019	DisNetworks ECMH PSB	44 44 53	LLP TTEC VISE	45 65 36	LangLit Giellagas HistCulCom Logo	63 14 81 19	EAF MAI MMI	35 13 46	Geography MathSci NANOMO NMR SpaceAstro EcoGen	42 35 42 22 34 82
Number of RUs per Faculty I Number of academic staff per faculty	3	141	3	146	4	177	3	94	6	257

	ITEE		MED		TECH		Regional units					
	ACM BISG CAS CMVS CWC-NS CWC-RT INTERACT M3S MIC OASIS OPEM UBICOMP	9 30 28 56 56 90 17 46 31 11 23 39	Biomedicine CancerTransMed CERH ELITE InternalMed MIPT Neuro OralHealth PEDEGO Surgery Nursing	36 44 15 53 22 67 17 43 54 15 18	ECE FPE IEM IMS Met MME OMS OSA SusChem CPE WE3 SCT	44 58 26 12 25 46 27 20 32 15 47 19	KUC	19	KSI	42	SGO	19
Number of RUs per Faculty I Number of academic staff per faculty	12	436	11	376	12	371	1	19	1	42	1	19

LIFELONG HEALTH
UNDERSTANDING HUMANS IN CHANGE
DIGITALIZATION AND SMART SOCIETY
CHANGING CLIMATE AND ENVIRONMENT
SUSTAINABLE MATERIALS AND SYSTEMS

Fig. 3.1. Faculties, research units and regional units aligned with UOULU's five focus areas. The focus areas are colour coded as indicated. The number of academic personnel is also indicated for each RU and faculty.

In the self-evaluation report, the RUs were asked to indicate which of UOULU's **five focus areas** best reflect their research interests. According to the responses, the RUs of five faculties (BMM, EDU, HUM, ITEE and OBS) identified only one focus area, whereas the RUs of three faculties (MED, SCI and TECH) had their main interests in more than one focus area (**Fig. 3.1.**). The three regional RUs each identified a different focus area, reflecting their distinct roles (**Fig. 3.1.**).

Moreover, the RUs were asked to indicate which of UOULU's **nine profiling areas** (see **Fig. 1.8.**) best reflected their research interests. As seen in **Fig. 3.2.**, in several of the faculties the RUs show diverse interests, and all three regional units identify themselves in distinct profiling areas (**Fig. 3.2.**). This data also serves to assess the number of RUs per profiling area.

Faculty / Regional unit	BMM	EDU	HUM	OBS	SCI
Research units	DisNetworks ECMH PSB	LLP TTEC VISE	LangLit Giellagas HistCulCom Logo	EAF MAI MMI	Geography MathSci NANOMO NMR SpaceAstro EcoGen
Number of RUs per Faculty	3	3	4	3	6

	ITEE	MED	TECH	Regional units		
	ACM BISG CAS CMVS CWC-NS CWC-RT INTERACT M3S MIC OASIS OPEM UBICOMP	Biomedicine CancerTransMed CERH ELITE InternalMed MIPT Neuro OralHealth PEDEGO Surgery Nursing	ECE FPE IEM IMS Met MME OMS OSA SusChem CPE WE3 SCT	KUC	KSI	SGO
Number of RUs per Faculty	12	11	12	1	1	1

Digitalized solutions for future heathcare (4)
Fibrosis in chronic diseases and cancer (8)
Strengthening human capabilities in the digital era (10)
6G solutions for data-driven society (9)
Dynamic data modelling (2)

Changing space environment (2)
Arctic interactions and global change (8)
Physics for sustainable steel (2)
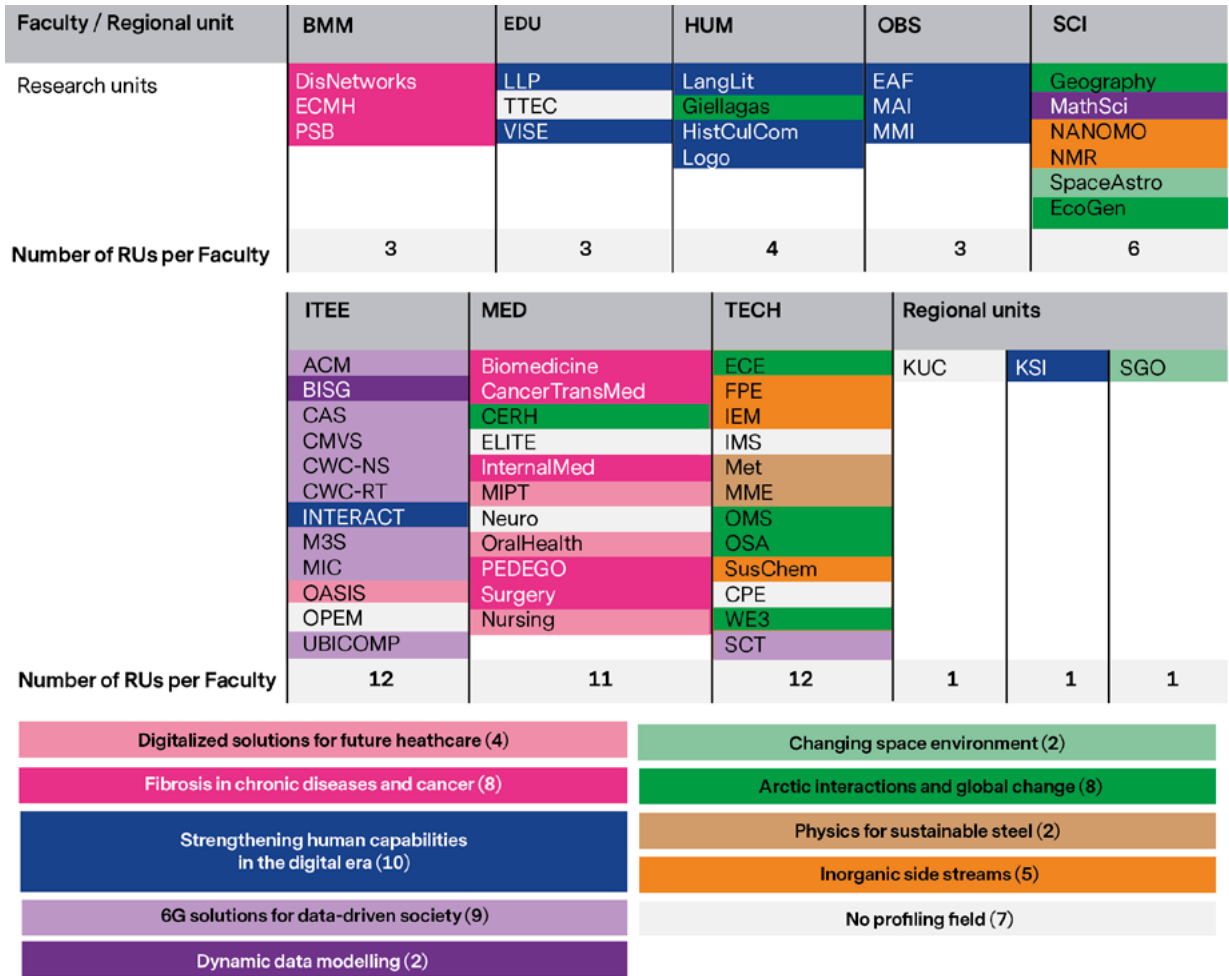Inorganic side streams (5)
No profiling field (7)

Fig. 3.2. Faculties, research units and regional units aligned with UOULU's nine profiling areas. The profiling areas are colour coded as indicated. The number of RUs is indicated in Profile field list.

As the main results of the UOULU **bibliometric analyses**, the researchers produced almost 15000 publications in 2013–2017, and the annual number of publications trended upwards over the period. The share of peer-reviewed scientific publications was predominant at over 80 percent. Moreover, 12 percent of the university's publication volume was intended for professional communities or for the general public. (**Fig. 3.3.**).

The full report on the publication analyses produced by the UOULU Library with descriptions of the methodology and the results in full for the university and the eight faculties are available in the final report of the library's analyses at http://urn.fi/urn:isbn:9789526231143.
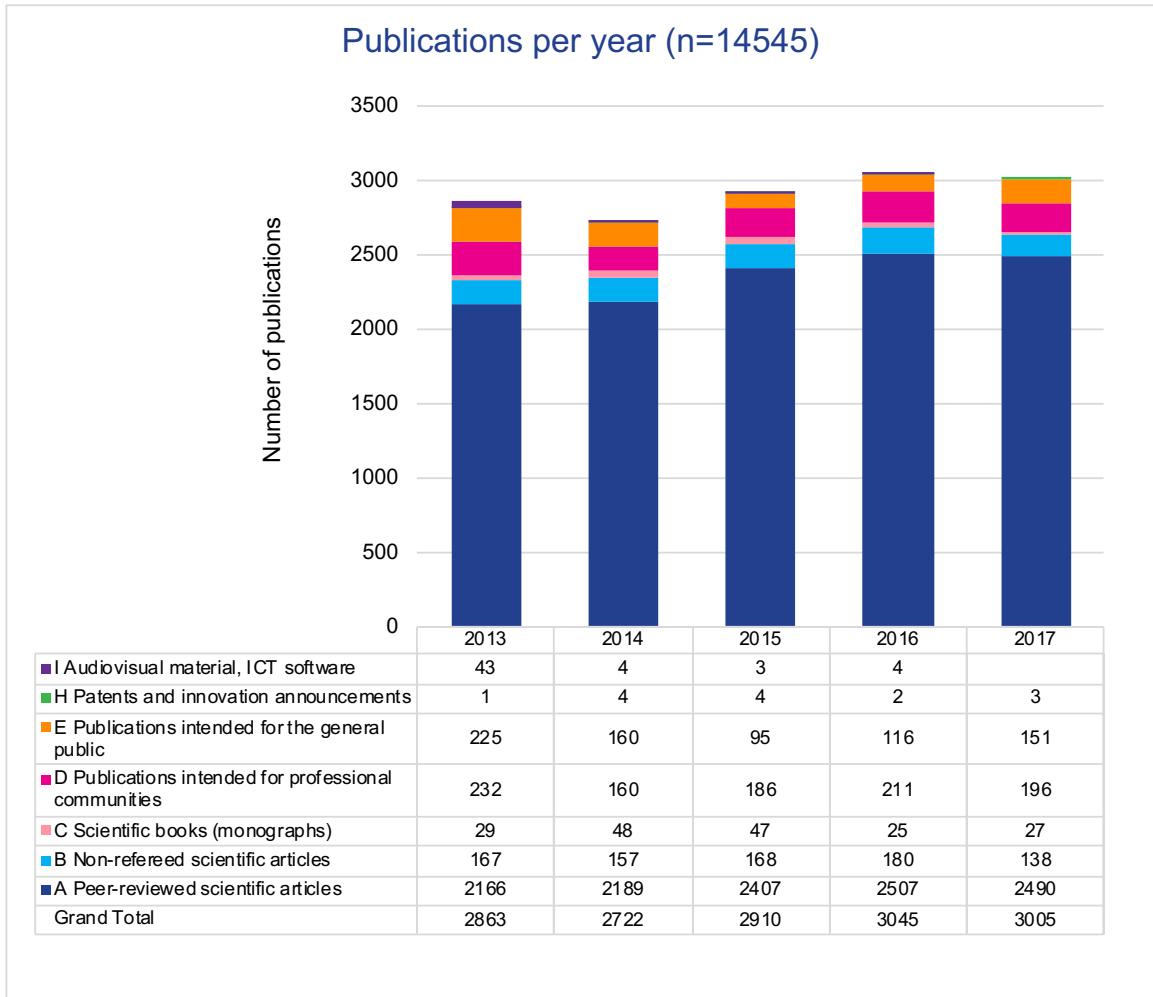
Publications per year (n=14545)

Number of publications	2013	2014	2015	2016	2017
I Audiovisual material, ICT software	43	4	3	4	
H Patents and innovation announcements	1	4	4	2	3
E Publications intended for the general public	225	160	95	116	151
D Publications intended for professional communities	232	160	186	211	196
C Scientific books (monographs)	29	48	47	25	27
B Non-refereed scientific articles	167	157	168	180	138
A Peer-reviewed scientific articles	2166	2189	2407	2507	2490
Grand Total	2863	2722	2910	3045	3005

Fig. 3.3. All publications of the university from years 2013–2017 in MinEdu publication categories A-I (excluding categories F Public artistic and design activities and G Theses)

The research performance analyses carried out by CWTS have been widely used in Finnish research assessment exercises. For the first time, CWTS also took conference papers into account in its analyses, which is worth considering when looking at the following results.

The Web of Science based analyses performed by CWTS included 57 percent of all UOULU publications during the period (8293 vs. 14545 publications). 82 percent of the publications involved collaboration with other organizations and 56 percent included international collaboration. Based on the two normalized performance indicators MNCS and PP [top10%], UOULU performed over 20 percent above the world average during the time period (**Table. 3.1.**).

Table 3.1. Performance indicators for UOULU at large. Full details of the indicators and results can be found in the CWTS final report on the research performance analysis for the University of Oulu 2013-2017/2019.

P [full]	8.293
Internal coverage	0.77
P [fract]	3.495
PP [collab]	0.82
PP [intl collab]	0.56
PP [industry]	0.08
TCS	110.057
MCS	13.26
MNCS	1.23
PP [top 10%]	0.12
MNJS	1.16

The collaboration profile of UOULU shows the important role of both national and especially international collaboration in publishing. International collaboration also had a positive effect on the values of the performance indicators, as the performance indicators show performance up to 40–50% above the world average. (**Fig. 3.4.**).
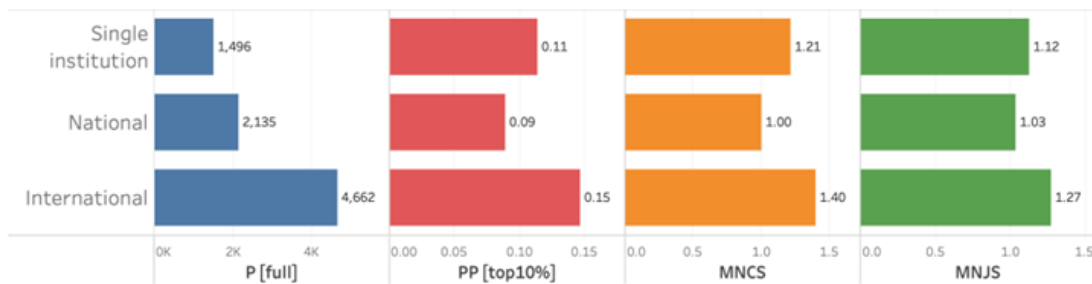
Fig. 3.4. UOULU collaboration profile, including the values of the output and impact indicators for the different forms of collaboration.

The CWTS also looked at the distribution of UOULU publications in different subject categories (defined by journal sets). The review shows how UOULU's publication production is distributed in a wide range of different research areas. Based on the number of publications, the Top 46 list of subject categories highlights research areas from almost all faculties of the university. Quantitatively, however, the subject categories of the ITEE and FMed faculties appeared to be the largest in the list. The citation impact of the categories were mainly above the world average in different subject categories based on both MNCS and PP[top 10%] indicators. (**Fig. 3.5.**).

A more detailed description of the methodology of the CWTS analyses and the results in full for the university and the eight faculties are available in the CWTS final report http://urn.fi/urn:nbn:fi-fe2021101551288
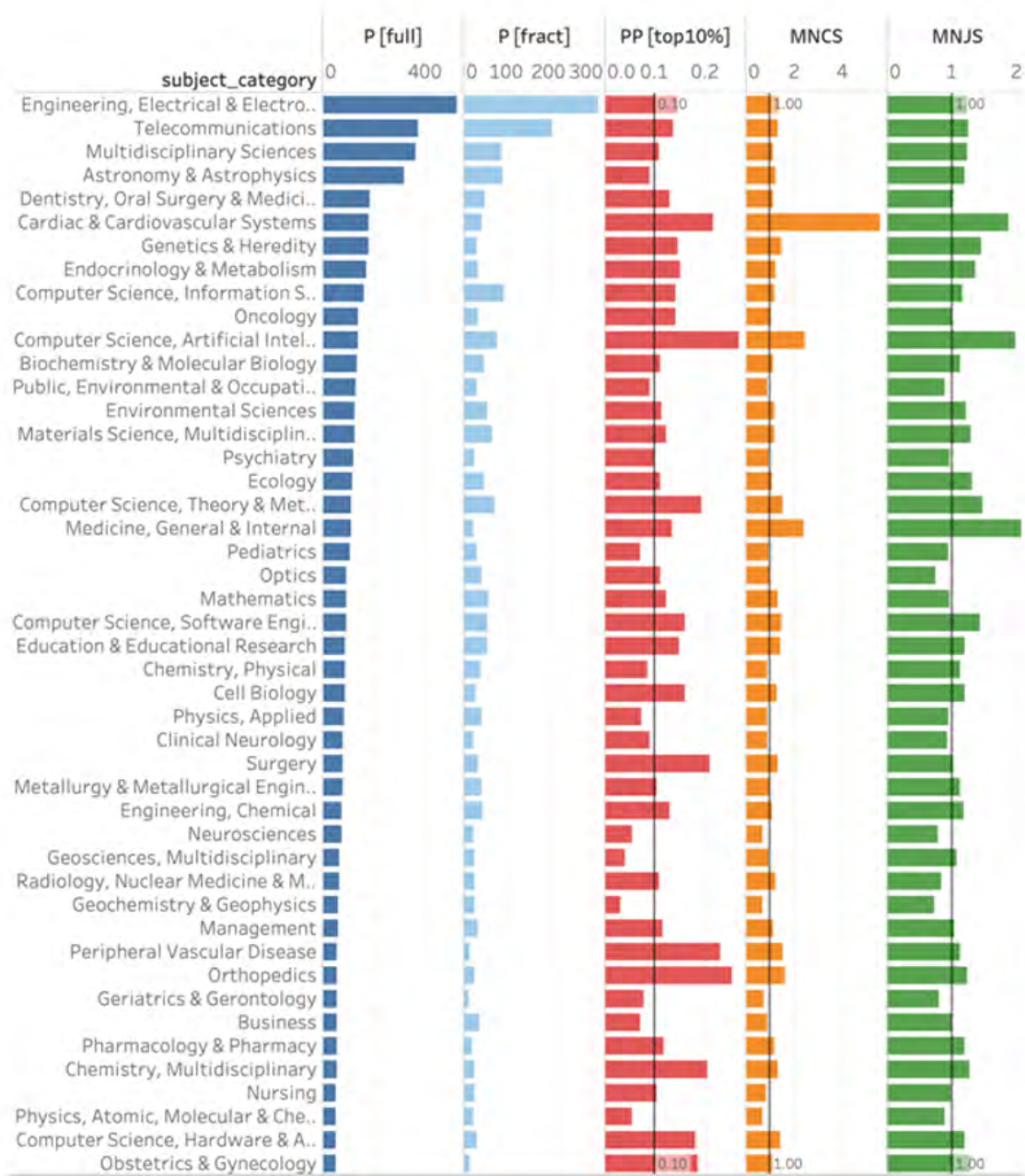
Fig. 3.5. UOULU research profile. The figure includes all subject categories with at least 50 publications.

UOULU supports building a responsible and sustainable society. As part of this programme, the RAE2020 assessment provided an excellent opportunity to assess how the RUs relate to the concepts of sustainable society as outlined at the global level by the United Nations Sustainable Development Goals (UN SDGs).

The compilation of the RUs' research work indicates the researchers at UOULU address all 17 UN2030 SDGs, **Fig. 3.6.**). The areas of most intense activities include Good health and wellbeing (SDG3), Quality education (SDG4), Industry, innovation and infrastructure (SDG12) and Climate action (SDG13).

UN Sustainable Development Goals (SDGs) and Research Units with the connection on a goal

1 NO POVERTY — 9	2 ZERO HUNGER — 6	3 GOOD HEALTH AND WELL-BEING — 31
4 QUALITY EDUCATION — 29	5 GENDER EQUALITY — 21	6 CLEAN WATER AND SANITATION — 13
7 AFFORDABLE AND CLEAN ENERGY — 14	8 DECENT WORK AND ECONOMIC GROWTH — 21	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE — 30
10 REDUCED INEQUALITIES — 15	11 SUSTAINABLE CITIES AND COMMUNITIES — 22	12 RESPONSIBLE CONSUMPTION AND PRODUCTION — 22
13 CLIMATE ACTION — 23	14 LIFE BELOW WATER — 6	15 LIFE ON LAND — 11
16 PEACE, JUSTICE AND STRONG INSTITUTIONS — 8	17 PARTNERSHIPS FOR THE GOALS — 14	

Fig. 3.6. The number of RUs targeting UN SD goals in their scientific action plans. The RUs were able to choose the goals that are relevant in their work from the 17 SDGs.

4. Assessment reports by panels

The evaluation results of the RUs with respect to overall scores and ranking by the three discipline-specific panels are shown in the **Table 4.1, 4.2** and **4.3**. The scoring scale ranged from 1 to 6, 6 being the best possible scoring. It should be noted that the ranking is not suitable for comparison between the panels and different scientific disciplines.

Table 4.1. The overall scoring and ranking of RUs evaluated by the Biosciences, Health and the Environment (BHE) panel.

RESEARCH UNIT NAME	SCORES	RANKING
ECMH - ECM and Hypoxia	6	1
Nursing - Research Unit of Nursing Science and Health Management	5	2
MIPT - Research Unit of Medical Imaging, Physics and Technology	5	3
DisNetworks - Disease Networks	5	4
ELITE	5	5
EcoGen - Ecology and Genetics	5	6
CERH - Center for Environmental and Respiratory Health Research	5	7
PSB - Protein and Structural Biology	5	8
Biomedicine - Research Unit of Biomedicine	5	9
CancerTransMed - Cancer Research and Translational Medicine Research Unit	5	10
InternalMed - Research Unit of Internal Medicine	4	11
PEDEGO - PEDEGO Research Unit	4	12
Surgery - Research Unit of Surgery, Anesthesia and Intensive Care	4	13
OralHealth - Research Unit of Oral Health Sciences	4	14
Neuro - Research Unit of Clinical Neuroscience	3	15

Table 4.2. The overall scoring and ranking of the RUs evaluated by the Culture and Society (CS) panel. RUs with the same ranking are listed in an alphabetical order.

RESEARCH UNIT NAME	SCORES	RANKING
Geography - Geography Research Unit	6	1
LLP - Learning and Learning Processes	6	1
Logo - Logopedics	6	1
VISE - Values, Ideologies and Social Contexts of Education	6	1
EAF - Department of Economics, Accounting and Finance	6	5
KSI - Kerttu Saalasti Institute	5	6
HistCulComm - History, Culture and Communication Studies	5	7
LangLit - Languages and Literature	5	7
Giellagas - Giellagas Institute	5	9
MMI - Department of Marketing, Management and International Business	5	10
TTEC - Teachers, Teaching and Educational Communities	4	11
MAI - Martti Ahtisaari Institute	4	12

Table 4.3. The overall scoring and ranking of RUs evaluated by the Natural Sciences and Engineering (NSE) panel. RUs with the same ranking are listed in an alphabetical order.

RESEARCH UNIT NAME	SCORES	RANKING
CWC-RT - CWC-Radio Technologies	6	1
Met - Process Metallurgy	6	1
MIC - Microelectronics	6	1
UBICOMP - Center for Ubiquitous Computing	6	1
M3S - Empirical Software Engineering in Software, Systems and Services	6	5
NMR - NMR Research Unit	6	5
SpaceAstro - Space Physics and Astronomy	6	5
CMVS - Center for Machine Vision and Signal Analysis	5	8
ECE - Environmental and Chemical Engineering	5	8
FPE - Fibre and Particle Engineering	5	8
IEM - Industrial Engineering and Management	5	8
KUC - Kajaani University Consortium	5	8
NANOMO - Nano and Molecular Systems Research Unit	5	8
WE3 - Water, Energy and Environmental Engineering	5	8
OMS - Oulu Mining School	5	8
CAS - Circuits and Systems	5	16
CWC- NS - CVC-Networks and Systems	5	16
INTERACT - Human Computer Interaction and Human-Centered Development	5	16
MathSci - Mathematical Sciences	5	16
MME - Materials and Mechanical Engineering	5	16
OASIS - Oulu Advanced Research on Service and Information Systems	5	16
SGO - Sodankylä Geophysical Observatory	5	16
IMS - Intelligent Machines and Systems	4	23
OPEM - Opto-Electronics and Measurement Techniques	4	23
Oulu School of Architecture	4	25
SusChem - Sustainable Chemistry	4	25
BIGS - Biomimetics and Intelligent Systems	4	27
ACM - Applied and Computational Mathematics	3	28
CPE - Chemical Process Engineering	3	28
SCT - Structures and Construction Technology	3	30

4.1. Biosciences, Health and the Environment (BHE) Panel

Panel members:

Professor **Robert Freckleton** (Panel Chair), University of Sheffield, UK - Professor **Trine Bilde**, Aarhus University, Denmark - Director **Bo Danielsen**, Copenhagen University, Denmark, - Professor **Rita Stagni**, University of Bologna, Italy - Professor **Harald Alfred Stenmark**, University of Oslo, Norge - Professor **Anna Strömberg**, Linköping University, Sweden - Professor **Aleksandra Trifunovic**, University of Cologne, Germany - Professor **Bruno Verges**, University of Burgundy, France - Professor **Paul Wilkinson**, London School of Hygiene and Tropical Medicine, UK - Professor **Alfried Vogler**, Imperial College London, UK

Research Fields of Panel for Biosciences, Health and the Environment:

biochemistry and biophysics – biomedicine - ecology and evolutionary biology – pharmacy - public health, environmental health and occupational health sciences - clinical medicine, dental science and veterinary medicine - agricultural, forest and food sciences – genetics - nutritional, sport and nursing sciences - cell biology, molecular biology and microbiology - environmental sciences - systems biology and bioinformatics related to the previous fields - other research into biosciences, health and the environment, including multidisciplinary research

Assessment results:

RESEARCH UNIT (RU)	Scientific quality and impact of the research	Societal impact of the research	Quality of the research environment	Future potential	OVERALL ASSESSMENT
Biomedicine - Research Unit of Biomedicine	Excellent	Very good	Very good	Excellent	Excellent
CancerTransMed - Cancer Research and Translational Medicine Research Unit	Excellent	Excellent	Excellent	Good	Excellent
CERH - Center for Environmental and Respiratory Health Research	Excellent	Outstanding	Very good	Excellent	Excellent
DisNetworks - Disease Networks	Excellent	Excellent	Excellent	Excellent	Excellent
ECMH - ECM and Hypoxia	Excellent	Outstanding	Excellent	Outstanding	Outstanding
EcoGen - Ecology and Genetics	Very good	Excellent	Excellent	Excellent	Excellent
ELITE	Excellent	Excellent	Excellent	Excellent	Excellent
InternalMed – Research Unit of Internal Medicine	Very good	Excellent	Excellent	Very good	Very good
MIPT - Research Unit of Medical Imaging, Physics and Technology	Excellent	Outstanding	Excellent	Excellent	Excellent
Neuro - Research Unit of Clinical Neuroscience	Good	Very good	Fair	Good	Good
Nursing - Research Unit of Nursing Science and Health Management	Excellent	Outstanding	Outstanding	Excellent	Excellent
OralHealth - Research Unit of Oral Health Sciences	Very good	Very good	Very good	Good	Very good
PEDEGO - PEDEGO Research Unit	Excellent	Excellent	Very good	Very good	Very good
PSB - Protein and Structural Biology	Excellent	Very good	Excellent	Excellent	Excellent
Surgery - Research Unit of Surgery, Anesthesia and Intensive Care	Very good	Very good	Very good	Very good	Very good

4.1.1. Research Unit evaluation reports of the BHE Panel (15 Research Units)

Research Unit of Biomedicine (Biomedicine), Faculty of Medicine
RAE2020 code: BHE 01

RU Leader:
Hakkola, Jukka

Professors:
Hakkola, Jukka – Hautala, Timo – Herzig,
Karl-Heinz – Hörkkö, Sohvi – Kerkelä, Risto
– Turpeinen, Miia - Vuolteenaho, Olli

Other PIs:
Magga. Johanna - Petäjä-Repo, Ulla

Academic Staff in 2019	36
Professors	7
Senior Researchers	4
Postdoctoral Researchers	3
Doctoral Students	17
Researchers on Personal Grant	5
In Teaching only	0
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	9

General description of the RU

The Research Unit of Biomedicine consists of three disciplines (Physiology, Pharmacology and Toxicology, and Microbiology and Immunology) and 8 research groups. The major research focus of the research unit is metabolic syndrome and associated diseases such as cardiovascular diseases, diabetes and fatty liver disease. We use methods of experimental medicine to improve prevention and treatment of metabolic and cardiovascular diseases.

Current description of the RU (rating 5)

The BHE 01 (Biomedicine) RU is composed of 3 disciplines: Physiology, Pharmacology and Toxicology, Microbiology and Immunology working together on a research axis focusing on "The determinants, mechanisms and novel therapeutics of metabolic syndrome and comorbidities". Although the size of the RU is moderate with members from different scientific backgrounds, the BHE 01 RU is performing very good research with excellent publications during the past years.

The general level of publication is good with 258 publications during the 2013-2017 period including a proportion of articles belonging to top 10% most highly cited publications of 0.09. During the oral presentation, we noted that the level of publication increased during 2018 and 2019.

Many members of the RU have performed research programs in collaboration with international groups indicating their expertise in the field and several members of the RU have responsibilities in scientific associations.

During the past years, the RU has been able to obtain several important national grants.

The senior researchers have an important teaching load which can affect their time for research.

Future potential of the RU (rating 5)

The objectives for the future are clear with a focus on the research dedicated to the determinants, mechanisms and novel therapeutics of metabolic syndrome and comorbidities. The RU is in good condition to continue and strengthen the active collaborations nationally and internationally. According to the program presented in the report, the RU is likely to produce high level data.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights of major scientific achievements:

The BHE 01 (Biomedicine) RU has a very good level and a recognized expertise in the field of the metabolic syndrome. The level of publication has significantly increased during the past two years.

Strengths and development areas:

The RU is in good position to perform a quality research program in the cardiometabolic field. The RU is in good condition to continue and strengthen the active collaborations nationally and internationally.

Recommendations:

The RU needs to think strategically more about recruitments and integration of more junior groups.

The RU should give more effort to find international funding.

Because the RU research program is now focusing on "The determinants, mechanisms and novel therapeutics of metabolic syndrome and comorbidities", it seems important to develop a tight collaboration between the different members of the RU.

Because the metabolic syndrome is highly present in many patients with diabetes or cardiovascular disease, the connection between the RU and medical departments seems limited and should be developed. The RU should try to have more clinicians involved in their research programs.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Cancer Research and Translational Medicine Research Unit (CancerTransMed), Faculty of Medicine

RAE2020 code: BHE 02

RU Leader:
Tuukkanen, Juha

Professors:
Lehenkari, Petri – Mäkinen, Markus – Salo, Tuula - Turpeenniemi-Hujanen, Taina – Tuukkanen, Juha – Vuolteenaho, Olli – Winqvist, Robert

Other PIs:
Pylkäs, Katri – Reunanen, Justus – Karihtala, Peeter – Koivunen, Jussi – Nyberg, Pia

Academic Staff in 2019	36
Professors	7
Senior Researchers	5
Postdoctoral Researchers	10
Doctoral Students	14
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	12
Docents (Adjunct Professors)	13

General description of the RU

Cancer and Translational Medicine Research Unit is a multidisciplinary unit that provides under- and postgraduate education for students of Medicine and Dentistry, MSc and PhD students, scientists, health care professionals and the public; conducts translational research; and provides patient centered medicine to prevent, diagnose and treat human illness. Cancer requires a new level of cooperation and pooling of resources in concerted effort with different resources and study groups to achieved new approaches to get knowledge and care for cancer. This requires collaboration in research and education and innovation at all levels (fundamental, translational, clinical and interventional).

Current description of the RU (rating 5)

The Cancer and Translational Medicine RU is a multidisciplinary unit including 7 academic subjects (Anatomy, Cell and Developmental Biology, Cancer, Breast Cancer Genome Medicine, Pathology, Oral Pathology, Clinical Chemistry) who developed a translational research program on cancer and inflammatory diseases. There is no overarching theme, but individual projects have made a significant contribution to theoretical understanding of biological mechanisms (studying genetics, gene expression, stem cells, etc.) and their implications in clinical settings. The main accomplishments are in treatment of brain lymphomas, genetic susceptibility to breast cancer, in vitro cancer testing, and histological classification of colorectal cancer. Some of the research conducted as part of large international consortia has potential to provide clinical benefit.

The RU is productive in terms of publication activity, with about 100 publications per year. These papers are highly cited. The RU has developed several national and international collaborations.

The discoveries originated from the RU have a significant impact on patient care. The discoveries on genetic susceptibility factors of hereditary breast cancer have already, as for PALB2, been translated into clinical utilization, for improved individual malignancy risk and better disease prevention and treatment.

Future potential of the RU (rating 3)

The scientific action plan is very superficially described (less than ½ page) and does not provide any particular visions other than continuing the ongoing (successful) research on breast cancer susceptibility, prognostic markers in oral cancers, and on characterization of biological pathways of carcinogenesis. It is not clear from the plan what is the RU's cutting-edge in these competitive research topics. It is also not evident how the scientific action plan complies with the research strategies of the University of Oulu, and with the UN Sustainable Development goals, although there does seem to be compliance based on the RU's previous achievements.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Very good research and expertise in the cancer field. However very limited vision on the future research plan.

Strengths and development areas:

The research goals are realistic for this RU which has a very good expertise in the cancer field. However, it is unclear to which extent the RU will succeed in unravelling novel cancer-host interactions during cancer progression and cachexia. The Scientific Action Plan is too superficial to estimate the impact of operational conditions and the RU's future viability.

Recommendations:

Financial support may be a concern in the future. The RU should try to get European or other international grants.

The RU has should recruit more international postdocs and PhD students. In addition, the RU should encourage their PhD students to have postdocs abroad. Overall, there is no doubt that there is potential for more international exchange, but incoming and outgoing in the interest of renewal of the RU.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Center for Environmental and Respiratory Health Research (CERH), Faculty of Medicin

RAE2020 code: BHE 03

RU Leader:
Jaakkola, Jouni

Professors:
Jaakkola, Jouni – Jaakkola, Maritta

Other PIs:
Ikäheimo, Tiina – Näkkäläjärvi, Klemetti

Academic Staff in 2019	15
Professors	2
Senior Researchers	2
Postdoctoral Researchers	6
Doctoral Students	4
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	5

General description of the RU

CERH is a research unit with multidisciplinary group of researchers with expertise in epidemiology and biostatistics, clinical medicine, biology, genetics, environmental sciences, ecology, geography and anthropology. Our mission is to promote human health in a changing global environment through multidisciplinary research addressing the topical global challenges, extensive international collaboration, providing education and consulting functions, and through contributing to national and international public health guidelines. We assess the health impact and burden of disease from environmental exposures directly or indirectly related to global environmental change. The ground-breaking approach is to apply multidisciplinary complementary research methodologies by conducting broad nationwide registry-linkage studies, follow-up of population-based epidemiologic studies, controlled experimental studies and synthesizing the evidence applying meta-analyses and burden of disease assessment. The results are applied to future scenarios that can be extrapolated to different parts of the world. Importantly CERH has been designated as WHO Collaborating Centre in Global Change, Environment and Public Health.

Current description of the RU (rating 5)

Current research performance CERH performs integrative and interdisciplinary research on the impact of the environment on health. The research unit perform high quality research through the partcipation in large national and international projects, which includes collaboration among many cities and countries. CERH is extremely well connected internationally, and was designated as WHO Collaborating Centre in Global Change, and Medical Research Center Oulu. The unit has an international and leading role in research linking environment to health.

CERH produces high quality research documented by a strong publication record, and by leadership of international research initiatives.

Research impact The collaborative efforts, international profile, and high quality of research results in high societal impact. CERH has a strong links to advisory boards, stakeholders, national and international health organizations, and policy makers, and contributes to initiatives, committees and other platforms that deliver scientific input for societal application. The unit is clearly very influential in the research field.

Future potential of the RU (rating 5)

Future plans CERH has a very ambitious plan for future research that aims to link global and environmental change to diseases and its impacts on health. The research programme will focus on the impact of climate change on public health, on the development of predictive tools to inform health care and health policy measures, on delivering scientifically informed mitigation strategies, and on developing key indicators for monitoring future environmental conditions and their impact on health. The proposed plan has the potential to deliver high impact research.

The research of CERH specifically addresses UN Sustainable Development Goal 3 (i.e. ensure healthy lives and promote well-being).

Research environment The unit works in a highly interdisciplinary manner, which spans other research departments, universities and stakeholders nationally and internationally. The strong integrative and collaborative research environment is key for advancing knowledge in the field.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

- CERH participates in comprehensive national and international research collaborations

- CERH leads relevant and high quality collaborations

- CERH has an important role of being a Research Center.

- CERH has numerous relevant academic and non-academic research partners and institutions. This profile is very important for transforming scientific advances to deliver societal and public health impact.

Strengths and development areas:

- CERH has substantial and impressive collaboration across faculties and research environments within the University of Oulu as well as across national and international institutions

- The integrative profile is key for supporting and developing multidisciplinary research on the influence of climate and environment change on disease and health.

Recommendations:

- The research infrastructure appears to be in place for the planned research plan.

- It is recommended to carefully plan the operational conditions, for example renewal or recruitment of personnel with complementary or relevant expertise.

- Furthermore, to focus on maintaining a competitive funding programme to secure adequate competitive research income to support the research programme.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Disease Networks (DisNetworks), Faculty of Biochemistry and Molecular Medicine
RAE2020 code: BHE 04

RU Leader:
Manninen, Aki

Professors:
Vainio, Seppo – Wei, Gonghong

Other PIs:
Kastaniotis, Alexander – Manninen, Aki

Academic Staff in 2019	44
Professors	2
Senior Researchers	3
Postdoctoral Researchers	15
Doctoral Students	23
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	5

General description of the RU

Disease Networks RU is composed of six research teams currently hosting an international staff of 50 people from 18 different countries. These six teams form a multidisciplinary unit focusing on understanding human diseases. The main approach is to establish novel and innovative study models where the genetic background and molecular complexity of selected diseases can be addressed. The aim is to unravel molecular mechanisms underlying normal and diseased organ functions and thereby provide means for more accurate diagnoses, development of novel diagnostics tools and reveal new potential drug targets for precision medicine research.

Current description of the RU (rating 5)

Overall the research at the DisNetworks RU is original and high-quality. The RU publishes some 20 papers per year, and average citation levels are good with about 8 citations/year per paper. Some of the papers are published in the most prestigious journals, and RU members are lead authors of important papers.

The RU has access to state-of the art infrastructures for imaging, proteomics, structural biology and transgenic mice and also makes important contributions to core facilities at Biocenter Oulu, including a virus core facility, an organoid analysis platform, and organotypic microfluidics platforms.

All the six PIs of the RU have strong CVs, and three of the PIs are international recruitments. They have all made important contributions to their research fields and have international recognition as reviewers, meeting organizers and organizers or PIs of international research cooperations. The RU members have extensive local collaborations and are also well networked at the national and international levels.

The RU was recently established, and it has a strategy for submitting joint grant applications in the near future. Since the RU's PIs have several international projects such as MSC CoFund and FET OPEN projects it is surprising that the level of international funding is low.

Future potential of the RU (rating 5)

The RU has the ambition to take on a nationally leading role as a developer of state-of-the-art organoid-based tissue models including organ-on-chip. The RU's research on disease models is of obvious interest to society as long as knowledge can be translated to the clinic. There are good plans for supporting spin-off enterprises that use the microfluidics and microtechnology platforms established by the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

DisNetworks RU performs original research of high quality, and its research groups all have good standings nationally and internationally, with well established collaboration networks.

The RU's research teams have quite diverse interests, but a common theme is the molecular basis of diseases. Different groups focus on diseases such as prostate cancer (Manninen, Wei), kidney/skin diseases (Vainio), fibrosis (Chen), and neurodegenerative diseases (Kastaniotis). Overall the research is original and in part based on cutting-edge scientific approaches such as organoid models and CRISPR-mediated single-nucleotide editing. The recent recruitment of Caglar Elbuken, a specialist in microfluidic systems, should facilitate the RUs' ambitious goals of developing organ-on-a-chip solutions disease and drug sensitivity modelling.

Strengths and development areas:

The strenghts of the RU are the strong international standing of the individual groups, their collaborations with national and international partners, their track record on high-quality research, and their interdisciplinary research portfolio.

Areas for future development include tighter collaborations between RU members and acquisition of international funding.

Recommendations:

- In order to take full advantage of the interdisciplinary expertise within the RU, the RU should make a strategy to increase contacts and collaborations between groups, both at junior and senior levels.

- Given the expertise of the RU members the focus on organoid models is a logical and realistic aim, and the RU should be well positioned to achieve scientific breakthroughs using the new technology. The RU should prepare a realistic time frame for this, as well as a contingency plan.

- The RU's members should take on leadership in applications for international grants, and should identify and promote candidates for ERC grants.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

ECM and Hypoxia (ECMH), Faculty of Biochemistry and Molecular Medicine
RAE2020 code: BHE 05

RU Leader:
Heljäsvaara, Ritva-Leena

Professors:
Eklund, Lauri – Pihlajaniemi, Taina –
Karppinen, Peppi – Kietzmann, Thomas –
Myllyharju, Johanna

Other PIs:

Academic Staff in 2019	44
Professors	5
Senior Researchers	3
Postdoctoral Researchers	10
Doctoral Students	26
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	6

General description of the RU

ECM-Hypoxia research unit (ECMH RU) consists of five internationally strong research groups which perform globally recognized research on the extracellular matrix (ECM), especially collagens, as well as hypoxia and vasculature in health and diseases. Increasing evidence points to direct links between the ECM, blood flow and oxygen availability. ECMH with its unique expertise and tools is in the frontline to study the interplay and joint contributions of these factors in tissue homeostasis and diseases, in rare congenital disorders and in common diseases such as cancer, fibrosis, and metabolic and neurodegenerative disorders, that affect millions of people worldwide, and constitute a major public health problem and economic burden to the society. Our goal is to understand the mechanisms underlying these diseases and provide new solutions to treat them in a globally sustainable manner. The research done at ECMH has strong traditions at UO and universal impact. The current studies represent the spearhead research at the relevant focus and profile areas of UO with significant potential for renewal.

Current description of the RU (rating 6)

The RU consists of five research groups that focus on extracellular matrix, vasculature and oxygen availability in tissue homeostasis. All five groups conduct original high-quality research and are well recognized internationally.

The RU publishes a good number of high-quality papers, mostly originating from the RU and some as part of international collaborations.

All the five group leaders of the RU have strong CVs with citation numbers ranging from about 4,000 to 10,000 and H-indexes ranging from 32 to 59. Several of the PIs hold patents, some of which have been key to establishment of enterprises. All research groups are well connected internationally and also have high international visibility as evidenced by reviewer and editorial board assignments, and memberships of academic committees and boards. Some of the group leaders also have experience as coordinators or participants in EU-funded consortia and projects.

Future potential of the RU (rating 6)

The RU's strategy is to build on its current strengths in extracellular matrix biology, oxygen responses and vascular biology and pursue the cause-effect relationships between extracellular matrix composition and tissue oxygen levels with chronic diseases such as obesity, fibrosis, cancer, and neurological disorders. The RU aims at improving synergies between the RU's groups and establish further interdisciplinary collaborations locally, nationally and internationally. Embedded in these plans are applications for a Finnish Centre of Excellence (unfortunately, this one was not funded) and an ERC Synergy Grant. The RU's plans connect well to the University of Oulu's focus areas on "Lifelong health" and "Digitalization and smart society" and are also in compliance with several of the UN Sustainable Development Goals. Overall the RU's plans are well-founded and forward-looking. The RU is in a good position to reach its goals since it already hosts a strong intellectual environment with excellent infrastructure, and since it is well-connected nationally and internationally. The RU's success in obtaining national funding provides a good starting point for further acquisition of international funding.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The RU ECMH is a very strong research environment, ranked as one of the best at University of Oulu. Only minor amendments are suggested by the review panel.

Strengths and development areas:

The RU's strengts are that it hosts a strong intellectual environment with excellent infrastructure, and that it is well-connected nationally and internationally.

Areas for further development include renewal of the RU's research environment, and acquisition of international funding.

Recommendations:

- The RU should make a formalized plan for renewal of its research environment, with emphasis on career development.
- The RU should make efforts to secure more international funding, for instance, by taking initiatives for joint international grant applications.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Ecology and Genetics (EcoGen), Faculty of Science
RAE2020 code: BHE 06

RU Leader:
Aspi, Jouni

Professors:
Aspi, Jouni – Häggman, Hely – Kaitala, Arja – Muotka, Timo – Oksanen, Jari – Watts, Phillip

Other PIs:
Eskelinen, Anu – Kallio, Eva – Kivelä, Sami – Pyhäjärvi, Tanja – Welker, Jeffrey – Mutanen, Marko – Virtanen, Risto – Koivula, Kari – Helanterä, Heikki – Kvist, Laura – Markkola, Anna Mari – Pirttilä, Anna-Maria - Taulavuori, Kari, Dinca, Vlad – Rytkönen, Seppo – Viljakainen, Lumi

Academic Staff in 2019	82
Professors	6
Senior Researchers	16
Postdoctoral Researchers	25
Doctoral Students	23
Researchers on Personal Grant	12
In Teaching only	0
Of these:	
Principal Investigators	22
Docents (Adjunct Professors)	19

General description of the RU

In Ecology and Genetics Research Unit high quality research is carried out in several research groups in various fields of biology. The main topics include (i) community, population, evolutionary and behavioural ecology, (ii) conservation, population and ecological genetics and genomics, (iii) biodiversity genomics and DNA-barcoding, (iv) ancient-DNA and domestication studies, (v) improvement of natural resources (e.g. forest, freshwater, wildlife, berries), and (vi) interactions between organisms of different trophic levels and ecosystem processes and vii) global change ecology and biogeochemistry. The emphasis in the unit is on basic research with some application linked to development of natural resources or lifelong health. Research of the unit have had a wide societal impact including environmental education and environmental legislation, co-operation with the general public and authorities in nature related issues, development of scientific platforms for scientist and general public, development of new medical treatments and even supporting creation of new spin-off companies.

Current description of the RU (rating 5)

EcoGen members conduct a range of diverse research broadly held together by the theme of arctic biodiversity. The topics include three broad areas, including research on arctic climate, genomic techniques in breeding arctic organisms, and biodiversity assessment (barcoding). Overall, most projects show a high degree of interdisciplinarity, in part stimulated by the collaborations within the unit and with groups across the faculties at Oulu. The EcoGen RU comes across as influential and active in the wider communities of a range of fields of biology, however the quality and impact of the different contributions are somewhat variable. The research output is good, given the size of the RU, and a good proportion of publications are in the highest Jufo 3 category. EcoGen members are represented in multiple national and international scientific boards and committees, as partners in EU projects, are involved in review panels, and contribute to other activities such as development of global biodiversity databases. The unit is well connected nationally and internationally, with multiple collaborative projects, networks and grants held jointly with other universities (mainly in Finland, Scandinavia and EU) and research institutes. The impact on society is through excellence of science, e.g., topics of climate change on weather patterns (snowfall) or intriguing experiments on bees to improve the public understanding of the importance of insect decline. Several research groups and their collaboration networks have clear societal and applied aims, particularly in the areas of resource use, ecosystem restoration, and conservation.

Future potential of the RU (rating 5)

EcoGen has an ambitious aim for developing excellence in research at the forefront of biodiversity and Arctic research. The RU is well set up to provide leadership in arctic ecology, by integrating the various research foci on freshwater, forests, insects and biodiversity. The planned research is strongly targeting relevant UN SDGs, and presents a range of research trajectories to deliver this research. This research is of great interest to society and eminently fundable. There is an ongoing generational change, with new hires predominantly in tenure-track positions, several of them only recently announced, and available positions have attracted high quality applicants. Great emphasis is on mobility at all levels from PhD students to senior staff, which adds to the future potential of the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

A substantial expansion of the biodiversity genomics (barcoding) programme has recently been funded by the Finnish Academy.

Recent high-profile papers on climate change have attracted great interest from the science community and general public.

Strengths and development areas:

The integration of different aspects of arctic biodiversity and sustainability research, together with a multidisciplinary methodological approach (from genomics, to ecosystem ecology and biogeochemistry) has great potential.

Recommendations:

The RU has the potential to deliver high impact research, and has potential for scientific leadership in several research areas. As presented, the future goals may not be sufficiently ambitious; the RU should take a more proactive approach and seek leadership *internationally.*

The RU would benefit from a more coherent approach for individual PIs to contribute towards developing an internationally leading role in focal areas. The unit should strive for greater integration, given the different disciplines represented. It is not clear what is the formal status of the "Biodiversity Unit" which appears separate from the Ecology & Genetics RU. Equally the arctic biogeochemistry group seems incompletely integrated with the other components.

The Action Plan has a very promising overall ambition, but without presenting a very concrete plan on how to deliver it. Clear, achievable goals are needed to capitalise on the unique sets of expertise and interdisciplinarity.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

ELITE (ELITE), Faculty of Medicine
RAE2020 code: BHE 07

RU Leader:
Timonen, Markku

Professors:
Ala-Korpela, Mika - Ala-Mursula, Leena – Auvinen, Juha –Järvelin, Marjo-Riitta – Kallinen, Mauri - Karppinen, Jaro - Kettunen, Johannes – Korpelainen, Raija – Laurila, Jouko – Miettunen, Jouko – Timonen, Markku

Other PIs:
Jääskeläinen, Erika – Ronkainen, Jukka – Strandberg, Timo – Sebert, Sylvain

Academic Staff in 2019	53
Professors	11
Senior Researchers	8
Postdoctoral Researchers	11
Doctoral Students	17
Researchers on Personal Grant	0
In Teaching only	6
Of these:	
Principal Investigators	14
Docents (Adjunct Professors)	16

General description of the RU

ELITE, the Center For Life Course Health Research (CLCHR) aims to sustainably provide excellence in research and training in two of the focus areas of the University of Oulu:

- Molecular and environmental basis of life-long health

- Digital solutions in sensing interactions

The CLCHR conducts research in life course and molecular epidemiology aimed at understanding health and aging, taking into account a number of modifiable and non-modifiable risk factors. The goal is to achieve a deep understanding of the following:

- Metabolic diseases, i.e. obesity, type 2 diabetes, cardiovascular diseases, hypertension, stroke

- Mental health, i.e. depression, anxiety, Alzheimer's and Parkinson's disease

- Musculoskeletal diseases

- Unhealthy aging

- Social inequality and health gradient

- Functional decline

Our research activity focuses on understanding ill health and the factors acting upon it to inform strategy for health promotion (early life), health preservation (aging) and prevention. We are also developing a large international consortium in early growth, life-course modeling and metabolomics to detect, amongst others, the causal pathways to long-term ill health by using large population multi-omics approaches. As a general perspective, the researcher in life course and molecular epidemiology aims at:

- Studying the association of multi-level risk factors for disease (or their underlying pre- clinical phenotypes) and understanding the interaction and the way the multilayers of risk operate through the life course.

- Discovering the genetic, epigenetic and other molecular pathways underpinning the risk of disease (or their underlying pre-clinical phenotypes) starting from early life

- Testing the causal inference of specific risk factors on the risk of diseases

- Establishing robust biomarkers of diseases and aging

- Stratifying diseases according to bio-psychological and social risk factors

- Consolidating data for open-access research in life-course health research

The CLCHR in Oulu trains early stage researchers at either master, doctoral student or postdoctoral level. The early stage researchers are taught in an international environment with team members from five countries, interacting in a truly European environment. The CLCHR is the coordinator of two large H2020 projects in health care (www.dynahealth.eu; Longitools.org) and a leading player in a recently funded H2020 LifeCycle project (coordinated by the Erasmus Center in Rotterdam) and the same goes for H2020-ITN Disc4All in which CLCHR is a leading player. In addition, CLCHR is a partner in a EUCAN-Connect project and EDCMET- project. In addition to these, the researchers within the CLCHR have been able to attract substantial funding from the Academy of Finland and other sources to implement their research strategy.

Current description of the RU (rating 5)

The BHE 07 (ELITE·CLCHR) RU is a large RU composed of 5 non-clinical groups (Computational medicine, Lifecourse epidemiology, Physical activity and health across the lifespan, Psychiatric epidemiology, Implementation) and 5 clinical groups (Geriatric epidemiology, Longitudinal outcomes in psychoses, Multi-morbidity in medicine, Musculoskeletal health, Working Life and health). The RU conducts research in life course and molecular epidemiology aiming to understand health and aging mostly focused on metabolic and cardiovascular disease, mental health, musculoskeletal diseases, unhealthy aging, social inequality and health gradient and functional decline. The RU has a great expertise and international recognition, is deeply involved in several international studies and shows an excellent level of publication.

Many members of the RU have performed research programs in collaboration with international groups indicating their expertise in the field.

The RU has a dynamic strategy to maintain its funding capacity by encouraging and supports all research staff-members to apply for funding at each stage of their research career.

Future potential of the RU (rating 5)

The RU will keep on working on the factors that contribute to maintain individual health and healthy aging process and translate these into clinical practices. The RU will strengthen its scientific output in some domains such as moving to longitudinal analyses and longitudinal models, supporting holistic data driven biopsychosocial models, triangulation of designs and methods pairing clinical and non-clinical research, combining and building database with multiple sources of data (clinical collection, registers, genetics…), disentangling causation, mediation and moderation, understanding the role of confounding mechanisms, multi-omics models and validation with causal inference methods, translating the research into policies, diagnostics tools, predictive models, path and protecting factors leading to functioning, improve secondary prevention (coronary heart disease/mental health).

The RU plans to develop Individual Participant data (IPD) meta-analyses.

The members of the RU have a good expertise and we may think that they should be able to achieve their research goals.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU has a great expertise and international recognition. The RU is deeply involved in several international studies and shows an excellent level of publication.

Strengths and development areas:

The RU is in very good condition to perform its future research program.

However, the RU has no full time statistician and it seems difficult to develop new epidemiological analyses (IPD meta-analyses, longitudinal models…) without more statistician time.

The report does not mention whether there is significant contact and collaboration between the different members of the RU working on different diseases (for instance, the members working on mental health and those working on metabolic and cardiovascular diseases).

Recommendations:

The RU needs to recruit statistician(s); this seems mandatory to to develop new epidemiological analyses (IPD meta-analyses, longitudinal models...).

The RU should improve the connections and contacts between the its 5 different groups (Computational medicine, Lifecourse epidemiology, Physical activity and health across the lifespan, Psychiatric epidemiology, Implementation).

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Research Unit of Internal Medicine (InternalMed), Faculty of Medicine
RAE2020 code: BHE 08

RU Leader:
Ukkola, Olavi

Professors:
Hukkanen, Janne – Junttila, Juhani –
Kaarteenaho, Riitta – Lunetta, Philippe –
Perkiömäki, Juha – Ukkola, Olavi

Other PIs:

Academic Staff in 2019	22
Professors	6
Senior Researchers	4
Postdoctoral Researchers	5
Doctoral Students	6
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	9

General description of the RU

The Research Unit (RU) of Internal Medicine conducts high-grade research under the leadership of professors, clinical instructors and docents. Research creates new knowledge and offers a possibility to review the customary health care practices and enable introduction of new diagnostic or therapeutic methods.

Current description of the RU (rating 4)

Internal medicine includes 5 groups in a broad range of different types of research with focus on 1) cardiovascular research on myocardial fibrosis, prediction and prevention of sudden cardiac death, 2) metabolic research on molecular mechanisms, treatment and counseling of obesity and related co-morbidities including fibrosis and 3) studies on fibrogenesis in severe lung diseases. 4) clinical endocrinology. The research activity and impact vary a lot between the groups. The activity in the endocrinology group is lower than in the others. The cardiovascular research has had a good impact of their research within sudden cardiac death and has national and international research collaboration with e.g. Johns Hopkins University in the US in gene expression studies. The digital web-based Health Behavior Change Support System and lifestyle counselling for overweight and obesity ("ONNIKKA") was developed at the research unit. This application has attracted Horizon 2020 EU funding until 2026 for the further development of ONNIKKA has been secured for the development of a new trial with the most high-risk ischemic heart disease patients.

The level of publication of the RU is good.

The 5 research groups are highly autonomous in the RU. We do not know how the 5 different groups of the RU of Internal Medicine collaborate together and the added value for the research. This unit shows a large heterogeneity between the groups which somewhat gives the impression of being more of a unit on a pure organisational level.

Future potential of the RU (rating 4)

The future research goals of the RU of Internal Medicine are:

1) Myocardial fibrosis in sudden cardiac death with the aim to find out clinical and genetic markers in order to find modifying risk factors for sudden cardiac death risk

2) To get further insight into the role of PXR on glucose and lipid metabolism with a focus on HDL

3) To study the effect of the ONNIKKA application in obese individuals with comorbidities

4) Liver fat and obesity related peptides

5) Familial pulmonary fibrosis with studies based on epidemiology, clinical course, genetic and pathologic data.

6) MEN-1 syndrome with a focus on genetic analyses

It seems that the research programmes on sudden cardiac death, PXR and ONNIKA are likely to give new significant data.

The project on liver fat is unprecise and there is great competition in that field. Because the RU has not worked so much on this topic, it is not obvious that new important data will be produced. We have the same concern for the research dedicated to MEN1 which has been developed at a high level by other groups in Europe and the USA. We would recommend performing collaborative studies in that field with other groups.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

Very good level of research for the groups working on myocardial fibrosis in sudden cardiac death and obesity.

However, the RU shows a large heterogeneity with no (or very few) interconnection between the 5 groups.

Strengths and development areas:

Research programs on sudden cardiac death, PXR and ONNIKA are promising. On the contrary, research programs on liver fat and NEM1 will be difficult to develop without any strong international collaboration.

The RU should develop more interaction between the 5 groups.

Recommendations:

The RU needs to develop real collaboration between the 5 different groups which are working on their own. The RU should develop combined research projects, joint grant applications, joint seminars for PhD students and senior researchers.

Members of the RU of Internal Medicine should try to be involved internationally.

Because external funding has decreased during the last years, efforts to obtain funding from EU sources should be strengthened.

The RU should also recruit foreigners and promote mobility of post-Docs outside Oulu University.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Research Unit of Medical Imaging, Physics and Technology (MIPT), Faculty of Medicine
RAE2020 code: BHE 09

RU Leader:
Tervonen, Osmo

Professors:
Jämsä, Timo – Kiviniemi, Vesa – Nieminen, Miika – Niinimäki, Jaakko – Reponen, Jarmo – Saarakkala, Simo – Tervonen, Osmo

Other PIs:
Liimatainen, Timo – Myllylä, Teemu

Academic Staff in 2019	67
Professors	7
Senior Researchers	7
Postdoctoral Researchers	13
Doctoral Students	38
Researchers on Personal Grant	1
In Teaching only	1
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	9

General description of the RU

MIPT is a multidisciplinary research unit at the University of Oulu, combining the expertise of PIs in clinical sciences (radiology, radiotherapy, clinical neurophysiology), medical physics, biomedical engineering, medical informatics, biomarker and biosensor development and connected health (business and economy). The unit capitalizes on both its physical and intellectual proximity to the local university hospital, which facilitates identification of real-life medical problems that require technological solutions as well as opportunities to test novel interventions in patients supported by clinical data. Its research can help to expedite diagnosis and treatment, improve diagnostic accuracy and better understand diseases that are of high significance to the society. To this end, RU members strive to develop and test new methods from bench to bedside, extending beyond the current state-of-the art, and to exploit the huge potential of modern imaging, spectroscopic and artificial intelligence techniques. Successful and impactful research is possible when combining basic research with knowledge of disease mechanisms and health.

Current description of the RU (rating 5)

The research unit has an excellent history of publications and the numbers of publications increases over time. The publication strategy is clear and far most of its publication are with open access. The composition of the researchers in the unit is multidisciplinary and half of the publications are done in collaboration with partners from within the University of Oulu.

RU researchers are highly active in international and national networks. The leaders of the research groups are well-positioned in their field. This is reflected in the network of collaboration that is evident from the publications, from the partnerships in consortiums that have achieved significant EU-grants and other competed research funding. This is also reflected in the staffs serving on international academic boards in other countries, substantial amounts of work as referees and editorial work for international scientific journals. Many have been pre-examiners of doctoral dissertations and have been reviewers of professorships at other institutions. Some have worked in different expert groups. The researchers from the RU are members of international scientific societies and many hold positions of trust in Oulu as well. Many have been participating in organizing international scientific meetings, workshops and conferences. Several of the professors have received awards and honors from international and national scientific societies. The research focus of the MIPT RU is clearly centred towards developing better diagnostics and treatment for patients. The RU has a clear understanding of how its research can contribute to the wellbeing and health of the citizens and to the sustainable development and prosperity of the society. Thus, the MIPT RU consider the societal relevance of its research as an important factor in planning its research activities. In perusing more efficient and more cost-effective diagnostics and treatments of common diseases and disorders the RU contribute importantly to the development of the healthcare system in Finland and abroad.

Research funding level is remarkable, with a constant increase over the last years. The RU has a strategy to pay attention to this aspect when recruiting senior researchers. The RU has a strategy to expand its efforts in acquiring research funding from North America, possible through joint funding applications with American collaborators as strategic partners. The RU has paid attention to the funding issues and have wisely allocated financial resources to seed funding of new types of research and make sure that talented individuals are not lost because of lack of carryover funding when there is a temporary stay in between projects. The unit's collaboration networks support multidisciplinary (medical and technological) research activity and its quality, providing complementary competences, supporting impact driven design and research translation, as well as providing essential patient cohorts and data-bases, and collaborative funding applications.

The research unit has a research infrastructure with clear procedures that support an excellent research environment.

Future potential of the RU (rating 5)

The RU plans to estabilish and expand the managment and research policy that supported the reported excellent research results in the past years. The excellent networking of the researchers of the RU and the remarkable level of the research competence support the proposed general future research goals, which can be considered reasonable and feasable. Moreover, the impact of passed research activities by the RU support the potential impact of future research development through the sustanance of the exhisting managment strategies. The RU took University strategies and UN sustainable development goals into account. On the other hand, the RU does not outline specific research activities to be developed or specific research targets to be fullfilled for its future strategy. No specific metric is provided for benchmarking current performance in terms of impact, nor to define specific expected future results. The RU proposes to quantify in the future the number of data-sets/tools made publicly available as development target, but no specific stategy, nor contingency plan is outlined to support feasibility and support future objective monitoring and verification.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The research unit is excellently managed and developed. The number of publications is increasing over time. The RU has well described strategies for development and has a very high affinity for attracting international competed funding. The unit has processes in place to identify potential new research areas and to develop them by means of efficient procedures for staffing and funding. The units is very active in educating doctoral students. The research management of the unit is very mature and has insight into areas where the unit can develop strategically.

Strengths and development areas:

The development of the RU's strategic focus, the units multidisciplinary work mode, the RU's inclusion of the University's strategic goals including sustainability, the success of acquiring significant competed research funding, the seniors researchers involvement in and contribution to the international research community, the increase in the number of scientific publications in recent years, and the education of substantial numbers of doctoral students are RU's strengths.

The RU might consider the definition of clearer and more specific development goals for each research area and of action and contingency plans to achieve such goals to support and enhance the development outcome.

Recommendations:

RU might benefit from considering Principal Investigators become more involved in the strategic development, and possibly valorize this potential. RU might benefit from systematic re-evaluations of the unit's procedures for development and recruitment. The units should keep devoting time and energy in staff development (e.g. make sure that all principal investigators master creating and support research networks and apply for large external competed research fundings).

Societal impact is integrated in RU research activity as closely related to patient diagnostics and treatment and human health. Nonetheless, what is referred to as 'inertia of the medical field' is likely to have delayed the measurability of the actual societal impact of the developed research within the monitoring time window. Some quantitative impact metrics, as well as quantification of time to research deployment, and/or evaluation of regulatory, economic, socio-cultural aspects hindering/delaying such deployment could better support the evaluation of the societal impact of the developed research, and serve as benchmark for future evaluations.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Research Unit of Clinical Neuroscience (Neuro), Faculty of Medicine
RAE2020 code: BHE 10

RU Leader:
Majamaa, Kari

Professors:
Leinonen, Ville – Mainio, Arja – Majamaa, Kari – Riipinen, Pirkko – Veijola, Juha

Other PIs:
Ansakorpi, Hanna – Katisko, Jani

Academic Staff in 2019	17
Professors	5
Senior Researchers	9
Postdoctoral Researchers	0
Doctoral Students	2
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	10

General description of the RU

RU Neuro harbors Neurology, Neurosurgery and Psychiatry. The disciplines are located separately in the campus with distances varying between 300 m and 1 km. The scope of research is clinical, but scientific interests are also directed to epidemiology and molecular research. Research in psychiatry also includes use of modern brain imaging methods. We aim to conduct research that will ultimately increase brain health in the population.

Current description of the RU (rating 3)

The RU Neuro is a recent RU (founded in 2015) gathering 3 disciplines (Neurology, Neurosurgery and Psychiatry) performing research on the brain. The scope of research is clinical but includes epidemiology and molecular research. During the past years, the RU has produced data on genetics of early onset Parkinson disease and set up the Finnish FTD Research Network, dedicated to the study of frontotemporal dementia, which combines basic and clinical research aiming to link molecular pathological alterations at the cellular level to clinical features in frontotemporal dementia patients. The RU has also provided new information on genes involved in the pathogenesis of schizophrenia. In addition, the RU reported functional brain imaging abnormalities in people at risk for developing psychosis.

The level of publication is not so high and among the 20 selected publications only 3 have been published in journals with Impact factors above 5. However, we have to notice that since 2017, the level of publication has increased with more articles in high-rank journals.

The total funding level is low and has to be increased.

The main concern is that there is no research collaboration between the 3 components of the RU: Neurology, Neurosurgery and Psychiatry. In addition, there is no common decision making for the RU.

Each group is focused on their own research. This combined with extremely low number of research staffs makes it impossible to perform research collaborations.

Future potential of the RU (rating 3)

The main projects of the RU Neuro for the future are to study:

1) the role of mitochondrial aberration in patients with Parkinson disease and early onset Parkinson disease with a focus on genetic variation associated with mitochondrial function

2) sarcopenia in Parkinson disease with a focus on mitochondrial function

3) both structural and functional MRI data in connection to various psychiatric risk factors and to connect the brain data to maternal health data during pregnancy in 1985 and 1986 (The Oulu Brain and Mind study)

4) cognitive functions in schizophrenia (part of the SUPER study)

Plans for future are either very specific for each individual research group or are extremely vague, not described at all, or lack common goals. This RU is not well unified and organized. It lacks any kind of structure that will make it a successful RU.

Highlights, strengths and development areas, recommendations and overall rating (3)

Highlights:

The main problem of the BH10 RU is a lack of unity. In addition, the number of researchers is low which is a major drawback to perform high level research.

Strengths and development areas:

The research on neurology and psychiatry is good when it is very poor for neurosurgery. The extremely low number of research staff makes it difficult to provide a fruitful research environment.

For the future, the RU Neuro will have to face an important problem: the need to find new young researchers to replace the senior researchers, who will retire soon. It seems that the pool of candidates among clinicians (neurology, neurosurgery and psychiatry) is presently limited in Oulu. The RU should try to attract researchers from other universities.

Recommendations:

The RU needs unification. If this unit is to exist in future, it has to drastically change its direction and dedication toward science. Recruitment and integration of additional junior research groups might provide new vigour obviously needed in this RU.

It is a good point to recruit clinicians to perform translational studies such as those aimed by the RU Neuro. However, the RU Neuro should consider to recruit also non-clinician scientists (epidemiologists, specialists in molecular genetic) to upgrade their translational research program.

The RU should also try to recruit more PhD students and post-docs. The RU should also consider including junior research groups.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

No connection reported.

Research Unit of Nursing Science and Health Management (Nursing), Faculty of Medicine

RAE2020 code: BHE 11

Primary panel: Biosciences, Health and the Environment
Secondary panel: Culture and Society

RU Leader:
Kyngäs, Helvi

Professors:
Kyngäs, Helvi – Kääriäinen, Maria

Other PIs:
Kaakinen, Pirjo – Kanste, Outi – Oikarinen, Anne – Suhonen, Marjo – Mikkonen, Kristina

Academic Staff in 2019	18
Professors	2
Senior Researchers	4
Postdoctoral Researchers	2
Doctoral Students	9
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	5

General description of the RU

The Research Unit of Nursing Science and Health Management is a strong and attractive research and education community and the northernmost university in the field. It provides Bachelor's, Master's and Doctoral degree education in two disciplines: Nursing Science and Health Management Science. RU leads GeroNursingCentre (GNC) established in January 2020. The research unit (RU) is part of the Faculty of Medicine, which is an essential element of the Life Sciences Campus Kontinkangas. The RU is situated next to the University Hospital of Oulu.

The mission of RU is to produce high-quality scientific research and educate new creative experts, researchers, educators and leaders in changing social and health care in partnership with the scientific community and the rest of society. We particularly promote the development of social and health care in Northern Finland with high societal impact through national and international cooperation. The unit has innovative experts in transformative and digital social- and health care, renowned for impressive research, innovative education and successful networking. Its working culture is based on values of courage, openness, flexibility, efficiency, resilience and humanity.

Current description of the RU (rating 5)

The research of the RU is innovative, creative and original in its pursuit of new approaches to digital well-being, lifelong health, restorative care and national clinical practice guidelines for nursing. It generates and synthesizes evidence concerning major themes in health and social care. It employs novel theories and promotes the renewal of evidence-based care path models to measure and enhance health care, health coaching/patient counselling and staff education and competence. It thus develops its related fields by directing them toward new research prospects theoretically and empirically.

Theoretically, its research is leading in composing its own frameworks, instead of just following a well-rehearsed and time-honoured beaten track. Empirically, by employing qualitative and quantitative research methods, the unit investigates field-related research questions concerning samples drawn from the Finnish and international population (e.g., children, youth and adults, chronically ill patients and older adults). The research groups in the RU have a strong focus on health and societal challenges for the population of Northern Finland, but conceptually these research questions are applicable to many other societies

in the Western World. The RU collaborates with an extensive network of important partners. It relies on person-directed values and promotes sustainable organizational and educational environments. Employing not only commonly used, but also pioneering methods (e.g., development of content analysis and predictive modelling and algorithmic clustering), the Nursing RU has secured its own space in international research. Finally, the unit offers to society future nursing research leaders, scientist and experts in the corresponding fields.

Future potential of the RU (rating 5)

A newly developed main research profile for the RU has been selected to be the digitalized solutions for future healthcare. This main profile is stated to include research from all the 6 research groups within the RU. The goal is to develop novel approaches to digital health and to support existing research in University of Oulu's profiling area (digital health). This novel profile entitled "Evidence-Based Digital Health Care (DigiHealth-EBHC)" is linked to a new strategy of University of Oulu (2020-2030) entitled DigiHealth 5G that highlights sustainable, digitalized and humane world and lifelong health. The RU clearly considers the societal relevance of its research as an important aspect of its activities and especially works to promote social and health care in Northern Finland. The focus on digital health is a timely research topic and clearly societally relevant both locally and internationally.

The RU has during the last years had a successful recruited strategy and secured the employment of a number of strong professors and junior researchers. There is good mobility of both incoming visiting researchers and post docs, while PhD students, post docs and researchers from the RU make longer or shorter research visits abroad. Recruitment and mobility support both continuity and renewal of the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU clearly considers the societal relevance of its research as an important aspect of its activities and especially works to promote social and health care in Northern Finland. The focus on digital health is a timely research topic and clearly societally relevant.

The RU has a strong partnership with other universities and health care facilities, and also collaborates with entrepreneurial companies within Finland.

The RU has a strong focus on producing evidence-based care and clinical guidelines for nurses. The RU produces a high number of systematic reviews yearly. It is noteworthy that they are affiliated to the Joanna Briggs Institute.

The RU has an extensive collaboration with many other national universities and health care units. The RU also collaborate with and have visited and been visited by a number of researchers from Slovenia, Japan UK, The Netherlands, Germany, Australia, Canada, Greece, and Cyprus.

Strengths and development areas:

The researchers in the RU seem to have a high work-load, but they also have clear strategy for finding a a sustainable balance between research, doctoral supervision and research-teaching. However, an increase in funding could further strengthen their innovative work and give more room and resources for research. An increase in external funding would help to further develop the future Scientific Action Plan of the RU and increase opportunities to conduct research that are internationally very strong.

They have a good national collaboration on research-teaching and a high number of PhD students, and a high research production so all three tasks seem to be balanced and handled in a good way.

The RU has a very good leadership and organisation including a well-developed and extensive long-term strategy for career development. Recruitment of staff has been successful and the faculty consists of many young promising researchers. The leaders of the RU clearly support the development of the staff members and carry out yearly evaluations of development and progress as well as 5-year career plans, with goals, development targets, training demands, evaluation of working community and management.

Publications from the RU are of high standard, and the publication strategy, which encourages publications in even higher-level journals, reasonably takes into consideration external, limiting factors such as those related to the fields per se (field-specific journals in lower Jufo classifications).

The proportion of publication with international collaboration, based on the related bibliometrics, is not high, but there is a clear strategy to strengthen this and the last years have shown an increase.

Recommendations:

Major recommendation:

Both the ongoing and planned research in the RU are innovative, creative, original and of good quality. Further, organization, leadership and collaboration are very strong so the main recommendation for the RU is to follow the chosen Scientific Action Plan for the coming 5 years.

Specific recommendations:

The strategy of broadening the publishing scope by trying not only strictly field-related journals but also interdisciplinary ones are encouraged for the RU researchers.

The RU prioritizes international research collaboration and exchange which is a strength. This is clear from activities and exchange visits, but less seen in joint publications. The number of publications including international researchers should increase.

Seeking additional external and internal funding is recommended to further strengthen the new innovative research programme "Evidence-Based Digital Health Care (DigiHealth-EBHC)".

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Research Unit of Oral Health Sciences (OralHealth), Faculty of Medicine
RAE2020 code: BHE 12

RU Leader:
Anttonen, Vuokko (in 2019) - Ylöstalo, Pekka (at present)

Professors:
Anttonen, Vuokko – Huumonen, Sisko – Pirttiniemi, Pertti – Sandor, György – Sipilä, Kirsi – Ylöstalo, Pekka

Other PIs:
Laitala, Marja-Liisa – Syrjälä, Anna-Maija

Academic Staff in 2019	43
Professors	6
Senior Researchers	11
Postdoctoral Researchers	14
Doctoral Students	12
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	8
Docents (Adjunct Professors)	8

General description of the RU

The Unit of Oral Health Sciences at the Medical Faculty, University of Oulu is performing clinical and applied oral and dental research in collaboration with the other research units of the Faculty and with other national and international collaborating units. The Unit of Oral Health Sciences publishes yearly about 70 publications, 90% of which are international peer-reviewed publications. The research topics of the Unit of Oral Health Science are interdisciplinary and related to different disciplines in dentistry. According to the strategy of the University of Oulu, the point in research has been focused on the Northern Finland Birth Cohort Studies and the use of high technology in the research of lifelong health.

Current description of the RU (rating 4)

The research at the OralHealth Research Unit (RU) is overall of very good quality in terms of originality, significance and rigour. Senior researchers and post docs publish on average more than two scientific publications per year (2019). In recent years the RU have publish about 70 publications yearly of which around 90% are peer-reviewed in internationally recognized journals.

Overall, the professors and senior researchers at OralHealth RU are highly active in national and international academic networks. They are invited as keynote speakers at international conferences and several act as referees and do editorial work for international scientific journals. Despite of this longer time in international laboratories is very seldom.

The Research Unit has a strong focus on development of diagnostic methods, cost and effectiveness of dental treatment. Together with large involvement in performing clinical work and consultations in the hospital sector staff of the research unit contributes to the well-being of the local citizens. Staff also publish a lot in Finnish for their colleagues.

The RU attract about 10% of its total funding from competitive sources with Finnish origin. Far most research projects are published together with national, international or local partners. During the last 10 years staff has been dramatically diminished without major changes in the organization of the Research unit. Thereby, resulting in some of the research groups becoming very small. The research unit have only few doctoral students.

Future potential of the RU (rating 3)

The research unit's strategic objective is through research to achieve alleviation of oral diseases for citizens. Many of the researchers at the research unit serve as experts working at dental specialist clinics or hospitals. The research program put forward will without doubt result in relevant outcomes that can improve and perfect diagnosis and treatment of patients. However, scientific objectives and goals of the scientific action plan leaves somewhat to be desired in order to be innovative and ambitious. The action plan builds very much on previous achievements and should be more innovative, be more interdisciplinary and be willing to take some risk taking up new areas.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The research at the Research unit is overall of very good quality in terms of originality, significance and rigour. Senior researchers and post docs publish on average more that two scientific publications per year. In recent years the RU OralHealth have publish about 70 publications yearly of which around 90% are peer-reviewed. Some of the professors and senior researchers at research unit are active in national and international academic networks. They are invited speakers at international conferences and several act as referees and do editorial work for international scientific journals. Some have been pre-examiners of doctoral dissertations and have been reviewers of professorships at other institutions. Some have worked in different expert groups. The reduction of staff the last ten years without reduction in teaching obligations seems to have caused some fatigue that have let to absence of innovation and creativity in the development of the organization and the research done here.

Strengths and development areas:

It is a strength that the RU collaborates and publish most of its research with national, international and local partners. This reflects many well-established collaborations. Together with new networks, this should be utilized for attraction of more external competed funding, including funding for more doctoral students. The Research unit has undergone a huge reduction of staff without a similar reduction in student load. Therefore, it might be expedient to make some consideration as to what extend a change in organizational structure of the research unit might be beneficial.

Recommendations:

- In light of the long period of staff reduction, it might be valuable to consider if there is a need for a restructuring of the Research units as there might be some potential in increasing the numbers of staff in the different research groups and teams that deliver the education.

- It might be worth to consider developing fora or procedures for creation of research proposals that could include more creativity and originality.

- The RU might benefit from developing a strategy for the involvement of the international and national partners in fundraising. This should preferable also include opportunities to include funds for more doctoral students. They might be able to contribute to more international mobility in the future, too.

- It could be considered how the RU can benefit from a more systematic and formal approach for developing interdisciplinary collaboration in order to expand and increase the quality of the research at the research. Collaboration with other disciplines and researchers from outside the RU are likely to not only to compensate for the disadvantages due to the staff reduction in recent years but it could become a boost in vitality of the research including several new important contemporary points of views at the different research projects. Those new could be sustainability, digitalization, patient's perspective etc.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

No connection reported.

PEDEGO Research Unit (PEDEGO), Faculty of Medicine
RAE2020 code: BHE 13

RU Leader:
Rämet, Mika (in 2019) - Tasanen-Määttä, Kaisa (at present)

Professors:
Alho, Olli-Pekka – Arvio, Maria – Ebeling, Hanna – Hautala, Nina – Kajantie, Eero – Martikainen, Hannu – Puistola, Ulla – Rämet, Mika – Serlo, Willy - Tasanen-Määttä, Kaisa – Uusimaa, Johanna – Veijola, Riitta

Other PIs:
Moilanen, Jukka – Sinikumpu, Suvi-Päivikki – Tapiainen, Terhi – Vähäsalo, Paula

Academic Staff in 2019	54
Professors	12
Senior Researchers	14
Postdoctoral Researchers	4
Doctoral Students	24
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	14
Docents (Adjunct Professors)	17

General description of the RU

PEDEGO Research Unit conducts basic and clinical research in its fields, which are

- Dermatology
- Otorhinolaryngology
- Pediatric Surgery
- Pediatric Neurology
- Child Psychiatry
- Pediatrics
- Clinical Genetics
- Ophthalmology
- Obstetrics and Gynecology

The research unit's acronym PEDEGO is also based on these disciplines (Pediatrics, Pediatric Neurology, Pediatric Surgery, Child Psychiatry, Dermatology, Clinical Genetics, Obstetrics and Gynecology, Otorhinolaryngology and Ophthalmology). The high level of the unit's research is reflected in the substantial amount of competitive research funding that its researchers have received. The most significant external funding has been granted for research related to the prevention of type 1 diabetes, gestational diabetes (GDM), mechanisms and consequences of premature birth and infertility, the health burden related to polycystic ovary syndrome (PCOS pediatric infectious diseases, genetics and mechanisms of early onset multiorgan diseases and dermatological diseases). In addition to research, PEDEGO is responsible for basic medical education as well as clinical and scientific postgraduate education. Pediatrics also organizes annually an international course in pediatrics.

Current description of the RU (rating 5)

The work of the RUt covers a diverse range of clinical fields and appears to be of high quality. A commendably high proportion entails collaboration at national and especially international level. In relation to the number of academic staff, the unit achieves a very good volume of publications, with a citation impact and portion of publications in the top 10% most highly cited that are in line with expectation. It has a reasonable level of competitively awarded researching (around Euro 1.4M in 2019 for 12 professors, 14 senior researchers). It has examples of important changes and improvements in clinical practice stemming from its research.

Due to patient care commitment, the RU does not have a specific publication policy, nor implements specific actions to promote open science. Although valuing research quality and competitiveness, the RU supports the importance of smaller papers allowing to communicate results that can be relevant for clinical evidence-based decision.

The number of publications (>800) is strong for an academic staff (including 24 doctoral students) of 54 and the average quality appears good. It is notable, however, the citation-based impact is somewhat higher for publications led by other institutions (1.31) compared with those led by the unit (0.82). This may in part reflect the unit's policy or to encourage publication of smaller, less high-profile research studies.

RU members have good collaboration networks, as well as participate in scientific and regulatory associations. Some RU members demonstrated significant competence in attracting research fundings at national and international level (EU and global).

The unit has an important emphasis on societal relevance and impact as appropriate for a unit focused on largely clinical research. Its research includes clinical trials and assessment of clinical diagnostics and procedures as well as genetic research, evidence reviews and other research. It has examples of practically important findings of importance to clinical practice. The level of impact appears reasonably high.

RU's approach appears to have been largely opportunistic rather than more focused and strategic. This may not be the optimal strategy for developing a coherent and high quality portfolio of research and for career development.

Future potential of the RU (rating 4)

The RU has a clear vision for its principal research goals and themes and recognises important ingredients for enhancing future success. It has a number of important resources on which it can capitalize for its future research. The general goal appears very ambitious.

On the other hand, no specific policy or methodology is outlined to pursue such goal, nor quantitative metrics/indices are suggested as reference benchmark or for assessment of the fulfillment of programmed goals in future assessments.

The (general) goals appear reasonably feasible – but are not articulated with detail. They depend in large measure on continuing success in obtaining competitive and collaborative research funding. It therefore seems important that a priority for the unit is to deploy measures that maintain and enhance that capability through internal and external cooperation.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The RU performs remarkably in terms of international collaborations and attraction of funding. The scientific production is very good although the impact of publications lead by foreign collaborators is significantly higher. The RU includes several research groups, performing differently.

Strengths and development areas:

Amount of funding collected is significant, and the international collaborations extensive, supporting the remarkable research performance of the RU. On the other hand, a more strategic approach to research development and staff recruitment could further improve such research performance.

Recommendations:

The yet remarkable performance of the Ru can benefit of a more strategic approach in publication policy as well as research activity planning, and staff recruitment. The definition and monitoring of objective performance indexes can support the implementation of such strategic approach.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

**Protein and Structural Biology (PSB), Faculty of Biochemistry and Molecular Medicine
RAE2020 code: BHE 14**

RU Leader:
Ruddock, Lloyd

Professors:
Kursula, Petri – Kursula, Inari – Ruddock, Lloyd

Other PIs:
Venkatesan, Rajaram – Bergmann, Ulrich – Juffer, Andre – Ohlmeier, Steffen – Glumoff, Tuomo – Kellokumpu, Sakari

Academic Staff in 2019	53
Professors	3
Senior Researchers	6
Postdoctoral Researchers	17
Doctoral Students	24
Researchers on Personal Grant	2
In Teaching only	0
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	7

General description of the RU

The study of protein structure and function is an essential part of biochemistry and of fundamental importance to biotechnology, medicine and the pharmaceutical industry. In the post-genomic era, protein science will be a key field in molecular biosciences, contributing significantly to both knowledge and understanding of normal and pathological biological processes. In addition, protein science will significantly contribute in the generation of knowledge and inventions to support wealth creation and an improved quality of life e.g. the use of protein structure-function relationships to discover molecules of therapeutic use against human diseases.

A major challenge for protein science over the coming decades will be to integrate the information obtained from in silico (computer), in vitro (test tube) and in vivo (cells or organisms) studies to produce an understanding of how individual proteins function within the complex, highly interactive, systems formed by cells and whole organisms. This ambitious goal will only be achieved by a multidisciplinary approach that utilizes both established and new technologies and encompasses the full spectrum of molecular biosciences. Structural, biophysical and biochemical analyses of proteins in silico, in vitro and in vivo can reveal the details of the molecular mechanisms by which proteins fold, are modified, form complexes and function. Only integration of these strands of research allows for a true understanding of protein function at the cell, organ or organism level. We are the only research community in Finland that integrates all these aspects into a single coherent whole.

The topics that the research unit works on include cancer, diabetes and other metabolic disorders, malaria, tuberculosis, membrane protein structure and function, synthesis of industrial enzymes, as well as small molecule drug development and of methodologies for efficient production of protein drugs. Research activities also address protein functional networks, the formation of large supramolecular complexes and the regulatory interplay between cells and intracellular organelles and metabolic compartmentalization in a physiological context.

Current description of the RU (rating 5)

The RU consists of 6 groups that focus on protein science with main emphasis on structural and biophysical aspects of protein biology. The RU has a good gender balance, and there is a strategy for development of the careers of younger scientists, including the assignment of three "emerging team leaders". Main research themes are protein complexes, mechanisms of proteins in biology and disease, and synthetic biology. Overall, the research published by the RU is original and of high scientific quality, to a large extent based on use of state-of-the-art technology. The members of the RU are well positioned

in their field, as evidence by their invitations to and organization of international conferences, membership in international committees and boards, and memberships of international research networks.

The RU publishes papers of high scientific quality with a mean output of about 30 papers per year and an upwards trend. The list of 20 selected papers shows examples of papers coming out from the RU in prestigious journals such as PNAS, PLoS Biology, NAR and Nature Communications.

The RU´s research has indirect implications for treatment of diseases such as malaria, bacterial infections and cancer and are thus of great societal relevance. Patents regarding production of disulfide-containing proteins have resulted in licences for use in biotech enterprises.

The RU has been successful in obtaining competitive external research funding, amounting to about 1.1 MEUR from national sources and 0.2M EURO of international funding in 2019. The RU has acquired instrumentation for equipment for protein production, biophysical analysis, structure determination and biocomputing, as well as a biosafety level 2 laboratory. Three of the RU´s PIs are coordinators for the Biocomputing and Bioinformatics, Proteomics and Protein Analysis and Structural Biology core facilities of BioCenter Oulu.

Future potential of the RU (rating 5)

The RU has a clear vision for its future research, which will be organized under three main themes – large protein complexes/networks, molecular mechanisms of biology/disease, and and synthetic biology/ bioengineering. This is to a large extent a continuation of current activities within the RU, but the RU will implement novel technologies and interdisciplinary approaches to further advance its science. The implementation of cryo-electron microscopy, a central technique for structural characterization of large proteins and protein complexes, will be instrumental for the RU´s further development. Because of the high expense of a cryo EM facility, it is uncertain whether such a facility can be funded. The RU should make a good contingency plan in case such funding cannot be obtained.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU´s groups collectively possess a strong expertise in protein science. They are well integrated in the national and international networks and are using different available European infrastructures including synchrotrons, XFEL, neutron sources and cryo EM facilities. Therefore, they are in a great position to develop proposed projects according to their plan. The main uncertainty relates to the implementation of cryo-electron microscopy. This methodology requires very high investments in equipment and buildings, as well as at least one dedicated person. The university should put efforts to ensure funding for this facility that is clearly in the core of RU's future development.

Strengths and development areas:

The RU is the most productive environment in Finland for structural biology with deposition of 60% of structures listed in PDB during 2016-2019.

The RU has been successful in obtaining competitive external research funding, that currently covers almost two thirds of their full budget.

The RU has two patents granted for the production of disulphide bond containing proteins, including therapeutic proteins, and this technology has been licensed for use in industry. Some of the compounds developed in this way are used have progressed to pre-clinical candidate state.

The RU´s members serve on various local, national and international boards and committees within research and education.

Recommendations:

The development of cryo electron microscopy (EM), a state-of-the-art technique that is central for the characterization of large proteins and protein complexes' structures, will be crucial for the RU´s further development. A clear contingency plan should be put in place in case the funding for the cryo EM facility does not go through.

Collaborations within the RU have so far been limited mainly to development of infrastructure and methodology. This is indeed important, but there is potential for more project-specific internal collaborations, as also noted by the RU.

The assignment of "emerging team leaders" is a very good strategy to ensure career development for the most talented young scientists in the RU's environment, but it is not clear to which extent there is international recruitment and personnel exchange although positions are advertised internationally.

The RU could have been more active in public dissemination of their science.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Research Unit of Surgery, Anesthesia and Intensive Care (Surgery), Faculty of Medicine
RAE2020 code: BHE 15

RU Leader:
Leppilahti, Juhana (in 2019) - Juvonen, Tatu (at present)

Professors:
Alahuhta, Seppo – Ala-Kokko, Tero – Biancari, Fausto – Juvonen, Tatu – Leppilahti, Juhana – Mäkelä, Jyrki

Other PIs:
Kaakinen, Timo – Liisanantti, Janne – Valkealahti, Maarit

Academic Staff in 2019	15
Professors	6
Senior Researchers	5
Postdoctoral Researchers	0
Doctoral Students	5
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	8

General description of the RU

The Research Unit consist of Surgery, Anesthesiology and Intensive Care. Surgery includes Cardiac Surgery, General and Gastroenteric Surgery, Orthopaedic and Trauma Surgery, Urology, Plastic Surgery and Hand Surgery.

Current description of the RU (rating 4)

The research of the RU is creative and solid in several fields: cardiac surgery, intensive care, anaesthesiology, general and gastroenteric surgery, trauma and orthopaedic surgery. The impact in the field is relevant both from the theoretical and especially from the empirical point of view, supported by a robust methodological approach.

The publication strategy is competitive, the number of publications is remarkable, with impact above average. In the last years, the number of publications has increased, also through an increase in research collaboration, while the impact remained more or less stable. Most peer-reviewed papers are published in Jufo level 1 and 2 journals, only less than 10% Jufo 3.

The RU members are well recognised in their specific fields of research, members of several association, scientific societies, and boards of regulatory and evaluation organizations.

The RU has relevant national and international collaborations supporting the production of relevant scientific research, as demonstrated by the fact that 86% of their publications are result of collaboration, 44% lead by the collaborating research centre, with slightly higher impact, than those lead by RU, but always above average. On the other hand, research funding is not described or analysed, according to the report it seems suitable to RU needs. No strategy for applying for external funding is described in the report.

The societal impact of medical research is intrinsic in the translation of the result into the clinical practice, improving health, interventions, wellbeing and survival of the patients, but also potentially reducing costs. All the examples reported in the report have certain societal impact, although quantitative indices characterizing such impact would better highlight its relevance and improve RU accountability.

Several national and international collaborations are listed in the report, without providing additional information regarding the nature, duration, and/or management or scope of such collaborations. On the other hand, these collaborations result to effectively support the scientific production of the RU.

The level of research produced by the RU is high, on the other hand no specific information is provided in the report regarding how academic culture or management structure contribute in research development.

Future potential of the RU (rating 4)

The scientific goals the RU has set for the future are innovative and ambitious, the potential impact is intrinsic to the type of scientific research planned. No specific information is provided as referred to University of Oulu's strategy.

According to the narrative description provided of the goals set in the future plan, the planned research is feasible, and existing collaborations will support the multicentric studies and data collection. Still, the identification of specific quantitative indexes would support results accountability for future assessment and monitoring, and a risk evaluation and contingency plan better support feasibility.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The research developed by the RU appears of good level, supported by competent staff and national and international collaborations. The quality and impact of scientific production supports the competence of the RU. On the other hand, little strategy seems to be applied in funding attraction and staff recruitment.

Strengths and development areas:

The strong involvement of the staff in clinical practice supports the quality of the research and its ready deployment.

The development of the unit and its performance could certainly benefit of a more strategic view and a more systematic management approach.

Recommendations:

The RU should develop a more strategic approach to research development and planning, funding attraction and staff recruitment.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

4.1.2. Panel BHE summary report

Overall assessment

The fifteen RUs that constitute BHE encompass a range of areas of biology, medicine, ecology and evolutionary biology. The size of the RUs vary enormously with some consisting of only a few principal scientists, whilst others are very large indeed. In all cases, there is a focus on research, and in general all RUs produce research outputs in high level international journals. The research units engage in outreach and industrial engagement and the panel was impressed by those RUs that were able to successfully engage in this way.

Overall, the panel scores indicate that the research of the BHE is very high quality. One RU was graded 6, nine were graded 5.

The RUs engage with a number of the strategic focus areas of the University, particularly" Lifelong Health", which is a major focus across BHE. There is some research that matches" Changing Climate and Northern Environment", however this is less extensive.

The proportion of income derived externally was variable. In some cases, this proportion was very low, and international funding (e.g. EU) was generally low (with some exceptions, where RUs from Oulu are playing a lead role in consortia). Overall the low proportion of external income was felt to be a weakness of BHE.

The internal organisation of the RUs was variable: in a number of cases, there were clearly extremely well-developed management structures and close integration of the unit. However, in others it was equally as evident that the group was less well integrated.

In terms of forward looking, we felt that most RUs had clear plans that aligned with the focus areas of Oulu University. In some RUs, owing to the career stage profile of the staff, it is clear that succession planning should be part of the forward-looking strategy.

Strengths and development areas

Strengths

- Excellent fit to "Lifelong Health" research focus

- All RUs recognise the need for internationally high quality publications

- Excellent examples of outreach and engagement of end users.

- Some examples of exemplary management and integration of the RUs.

- Generally excellent plans for strategic development.

Weaknesses

- External income: a weakness for a large proportion of the RUs.

- Succession planning: reliance on small numbers of senior staff in

- Integration across RUs: some good examples, but could be improved

- Critical mass: some RUs are very small, and this limits their impact

Development areas

- Some RUs are small and some are not well integrated.

- Succession planning: some small RUs are dependent on a small number of senior researchers. Without a plan for recruitment of junior staff, there is a danger that these RUs will not be sustained.

- External income could be improved, but may need support, e.g. through investing in research support.

- The best practice in those RUs with excellent management structures could be spread more widely.

Good practices and recommendations

Good practices

There is a focus on high quality outputs, ensuring that RUs are ambitious to be at the forefront of their fields. At the same time, it is recognised that scientific outputs in the widest sense are important, with many exemplars of engagement of RUs with end users. The engagement with end users includes both international and national audiences, and ensures that society benefits from the research of these RUs at local as well as higher levels.

There are well organised RUs with well-developed, inclusive management structures. These foster career development, training of scientists as well as strategic thinking about the future of research.

Recommendations

The smaller RUs may find it difficult to make an impact in international terms, and we would recommend that the smaller units consider whether they would be better as part of larger ones. The environmental and ecological work is high quality, but not well integrated with the rest of the RUs in the BHE. This is addressing the University focus area of "Changing Climate and Northern Environment", but this could be developed further. Acquisition of external funding should be promoted in order to broaden the base of research as well as to provide resilience – more diverse funding streams mean that RUs are robust to changes in local funding availability.

4.2. Culture and Society (CS) Panel

Panel members:

Professor **Marianna Papastephanou** (Panel Chair), University of Cyprus, Cyprus - Professor **Jüri Allïk**, University of Tartu, Estonia - Professor **Peter Aue**r, Universität Freiburg, Germany - Professor **Mona Domosh**, Dartmouth College, USA - Professor **David H. Kaplan**, Kent State University, USA - Professor **Margus Pedaste**, University of Tartu, Estonia - Professor **Thomas Plenborg**, Copenhagen Business School, Denmark - Professor **Teemu Ryymin**, University of Bergen, Norway - Professor **Judith Zolkiewsk**i, University of Manchester, UK

Research Fields of Panel for Culture and Society:

philosophy - history and archaeology - educational sciences - linguistics - law - psychology - social sciences - art research - economics - theology - political sciences - communication sciences - sociological environmental research and human geography - other research into the humanities and social sciences, including multidisciplinary research

Assessment results:

RESEARCH UNIT (RU)	Scientific quality and impact of the research	Societal impact of the research	Quality of the research environment	Future potential	OVERALL ASSESSMENT
EAF - Department of Economics, Accounting and Finance	Outstanding	Excellent	Excellent	Outstanding	Outstanding
Geography - Geography Research Unit	Outstanding	Outstanding	Excellent	Outstanding	Outstanding
Giellagas - Giellagas Institute	Excellent	Outstanding	Excellent	Very good	Excellent
HistCulComm - History, Culture and Communication Studies	Excellent	Excellent	Excellent	Excellent	Excellent
KSI - Kerttu Saalasti Institute	Excellent	Outstanding	Excellent	Excellent	Excellent
LangLit - Languages and Literature	Excellent	Excellent	Excellent	Outstanding	Excellent
LLP - Learning and Learning Processes	Outstanding	Excellent	Outstanding	Outstanding	Outstanding
Logo - Logopedics	Outstanding	Outstanding	Outstanding	Excellent	Outstanding
MAI - Martti Ahtisaari Institute	Very good	Excellent	Very good	Very good	Very good
MMI - Department of Marketing, Management and International Business	Excellent	Very good	Excellent	Outstanding	Excellent
TTEC - Teachers, Teaching and Educational Communities	Very good	Excellent	Excellent	Excellent	Very good
VISE - Values, Ideologies and Social Contexts of Education	Outstanding	Outstanding	Outstanding	Excellent	Outstanding

4.2.1. Research Unit evaluation reports of the CS Panel (12 Research Units)

Department of Economics, Accounting and Finance (EAF), Oulu Business School
RAE2020 code: CS 01

RU Leader:
Kallunki, Juha-Pekka

Professors:
Järvinen, Janne – Kallunki, Juha-Pekka
– Kopsakangas-Savolainen, Maria –
Korhonen, Marko – Perttunen, Jukka
– Puhakka, Mikko - Sahlström, Petri –
Simonen, Jaakko – Svento, Rauli

Other PIs:
Joenväärä, Juha

Academic Staff in 2019	36
Professors	9
Senior Researchers	1
Postdoctoral Researchers	10
Doctoral Students	15
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	not reported

General description of the RU

The Research Unit of Economics, Accounting and Finance ("RU" hereafter) currently has about 35 faculty members working in 7 research teams. Our research in economics focuses on behavioral topics in economics by examining occupational choice and personality, labor market and health outcomes, and economic impacts of physical activity and sedentary behavior. Economics research also focuses on environmental and energy economics by exploring the role of renewable energy in electricity markets, regulation and dynamic pricing in flexible energy systems, and the effect of global warming on the environment. In accounting, we examine the role of managerial traits in insider trading, tax non-compliance and other business outcomes by exploiting unique person-level data on managers. Our accounting research also covers management control systems and public sector accounting. In finance, our research focuses on behavioral finance, using a combination of register data on stockholdings and detailed data on individual investors' personal characteristics. Our faculty members have track records in publishing in top-tier journals, including those included in the Financial Times 50 –list. We produce about 100 MSc graduates in our master programs every year.

Current description of the RU (rating 6)

The RU has a clear research strategy aiming at publishing in high-quality international peer-reviewed journals such as those included in the FT-50 list or ABS4 category. The RU is engaged in multidisciplinary research that makes use of links with the medical faculty and uses the Northern Finland Birth Cohort data to inform their research. This data is used to provide insight into economic and financial behaviour. This is creative and original, and the good level of citations is indicative of the impact of this work. The novel contributions lie in relating this data to theoretical areas of interest, e.g., investor's behaviour.

The RU has a sound academic culture and strong research leadership. It seems that the recent organizational changes have facilitated the development of an even stronger, mutually supportive culture that is conducive to joint working. The increase in cooperation has resulted in successful research funding bids and production of academic papers as noted above.

Future potential of the RU (rating 6)

The RU has ambitious but achievable objectives. One example is the goal of the behavioral economics researchers to make a breakthrough in behavioral economics research by utilizing unique research opportunities of utilizing medical and psychological data received from the Northern Finland Birth Cohort (NFBC) in exploring economic risk behavior. Another example is the resilience research team that explores how the processes of individuals, communities and societies can be made stronger and more resilient as they use and develop intelligent and digital technologies.

It is regarded as very likely that the RU will succeed in producing new significant outcomes due to

- novel ideas

- the RU's track record

- the access to unique data

- its close collaboration with other research units at Oulu (and other universities) and

- the great pool of talent among doctoral student and postdocs.

The RU addresses research questions with potentially high societal impact. This is clearly illustrated by the two examples above.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights of major scientific achievements:

- The RU (cleverly) focused on areas where they have a distinct expertise and a clear competitive advantage to other researchers within the same domain. The RU seeks to exploit their access to proprietary data that allows examination of important and unique research questions.

- The RU has developed a research strategy aiming at publishing in high-quality international peer-reviewed journals

- The RU has succeeded in publishing in high-quality journals such as those included in the FT-50 list or ABS4 category

- The bibliometrics suggest a deal of variation in the impact of their work but the most recent reported data (2017) is very good (MNCS[fract] 1.58)

- The RU has developed strong collaborations with excellent international scholars resulting in top publications. The level of collaboration is very high also internally, among RUs of UOULU where collaboration is inclusive, diverse and rich, serving multidisciplinarity and cross-disciplinary thought-enlarging encounters.

Strengths:

- The RU has a clear research strategy aiming a publishing in journals listed on the FT-50 list or ABS4 category

- The RU is able to examine research questions that are difficult to address by other researchers due to the access to the unique proprietary data. This allows the RU to develop new knowledge of interest not only the local (Finnish) society but also an international audience.

- The RU has a strong faculty

- The RU cleverly collaborates with international scholars where it benefits from such collaborations

Development areas:

- The RU notes that "there is room to improve in publishing in top tier journals, i.e. journals included in the FT 50 list, ABS 4 level, or in the JUFO3 level of the domestic journal ranking". It suggests that RU is aware of where they need to build further skills to strengthen their outputs even more.

- The RU benefits from access to unique proprietary data as well as standard financial databases such as Thomson Reuters. An issue of concern is that the legal department has been unwilling to approve the purchase of the most recent years of data from Euroclear, despite current possession

of previous years of the data and compliance with all GDPR requirements. Such restrictions may potentially harm the ability to conduct research within the RU. Furthermore, such restrictions may also affect the motivation of the affected researchers negatively.

Recommendations:

We recommend that the RU builds on its current research strategy, which has served so well in the past years. This implies that the RU

- Maintains (and develops) its ambitious research strategy

- Exploits the access to unique data even further

- Develops faculty so that research output can improve in line with their own ambitions and goals ("there is room to improve in publishing in top tier journals, i.e. journals included in the FT 50 list, ABS 4 level, or in the JUFO3 level of the domestic journal ranking")

The RU is primarily a publicly funded institution and the commitments toward the Finnish society that emerge from this status is crucial. Hence, it is important that the RU also supports its societal impact by actively writing for the public readership and by placing this aspect of its productivity side by side with the aspect that concerns its growing international visibility.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Geography Research Unit (Geography), Faculty of Science

RAE2020 code: CS 02

Primary panel: Culture and Society
Secondary panel: Natural Sciences and Engineering

RU Leader:
Saarinen, Jarkko

Professors:
Hjort, Jan – Lujala, Päivi – Paasi, Anssi –
Saarinen, Jarkko

Other PIs:
Alahuhta, Janne – Prokkola, Eeva-Kaisa
– Ridanpää, Juha – Antikainen, Harri –
Nishiyama, Hidefumi - Sitomaniemi-San,
Johanna – Tervo-Kankare, Kaarina

Academic Staff in 2019	42
Professors	4
Senior Researchers	5
Postdoctoral Researchers	12
Doctoral Students	19
Researchers on Personal Grant	1
In Teaching only	1
Of these:	
Principal Investigators	11
Docents (Adjunct Professors)	8

General description of the RU

Geography Research Unit (GRU) provides an internationally well-known, active and attractive working environment with a global research scope. The Unit has specific research areas in human and physical geography, which offer significant synergy to each other and possibilities for a dialogue between scholars. The general shared aim of the Unit is to perform theoretical and empirical research that helps to understand regional change and explain global problems at and across various spatial scales. The Unit's researchers contribute to the solutions of global problems by addressing the sustainable development of society and the environment. Leading research themes are integrated in the University's focus areas of Understanding humans in change and Changing environment of the North. A substantial part of the Unit's research has an arctic emphasis. According to international rankings, the Unit has steadily been among the strongest at the University. This high quality is demonstrated by the fact that the Unit held the first Academy Professor (2008-2012) and the first Center of Excellence (2014-2019) in Finnish geography, both nominated by the Academy of Finland.

Current description of the RU (rating 6)

The Geography Research Unit (GRU) is comprised of an internationally recognized and respected group of scholars who produce research that is making critical and compelling contributions to several important fields of study. It does so in each of its four major areas of research. Members of the unit publish at an extraordinarily high level, with an annual average of 75 publications in a team of 42 academic staff. The quality of these publications can be assessed by the fact that most such publications fit within levels 1-3 of the JUFO rating system, and that the citation impact is higher than the world average for the unit as a whole.

Members of the GRU are prominent in their field and highly influential. They have been awarded very prestigious prizes from international bodies, hold eminent positions in leading scientific panels and organizations, and act as evaluators of academic excellence at various international universities. The members of the GRU are very keen collaborators at the international level, but also at the internal and national level, and these collaborations have led to important contributions to the global research community.

All of the research pursued at Oulu Geography has significant societal impacts. Each of the four primary research areas make significant contributions to the critical issues of our contemporary life, including environmental sustainability in the Arctic, refugee resettlement, rising nationalisms, equity issues within tourism, and conservation planning. The members of the Geography RU routinely apply for and receive external funding from national and international organizations for their research at a scale that is very robust compared to the hard sciences or engineering.

The Geography RU has a solid plan of supporting research. It is well governed with a Head who is appointed for a four-year term, supplemented with a Steering Group of professors, postdocs, and students. This structure works well to provide academic leadership and forge pathways for the promotion of junior scholars.

Future potential of the RU (rating 6)

The goals and objectives of the Geography RU are clear, ambitious, and align both with the University's strategic goals and with the UN sustainable development goals. Members know where they want to go with their research, why that research is important, and how they plan to get there.

Each research cluster has innovative plans to move their current research into new and innovative arenas, including the challenge of understanding places as bounded and unbounded at the same time, climate migration, environmental justice, the challenges of decreasing biodiversity, and ecosystem sciences. These areas of research are at the cutting-edge of social scientific and scientific research and have huge societal impacts.

The RU's development targets are eminently feasible, assuming that the present levels of funding continue and that the staff are given the time and space to work on their research. The RU is in a very strong position, and its members show not only the ambition but also the capability to further increase the quality and the societal impact of their research in the next decade.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The University of Oulu Geography Unit is an important center for research in several areas of geography. It has internationally recognized professors, it overperforms other units of its size, and the research it produces is highly impactful within the academy and within society. It is an incredible resource within Finnish geography and in Geography around the world. This prominence was underlined by its designation as a Center of Excellence by the Academy of Finland.

Strengths:

- Internationally recognized professors producing cutting-edge research
- Publication citations that are well above the global average.
- Good record of collaboration with other institutions in Finland and around the world.
- Success at securing competitive funding, especially from the Academy of Finland.

Development areas:

- The internationalization of students/faculty
- International funding only a small proportion of overall research funding
- Percentage of doctoral students who graduate each year is low
- Geoinformatics cluster needs more staff

Recommendations:

- Find more successful methods of recruiting international students and staff

- Increase graduation rate of doctoral students

- Make sure to increase staff, including a professorship, in Geoinformatics

- Try to improve the amount of international funding

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Giellagas Institute (Giellagas), Faculty of Humanities
RAE2020 code: CS 03

RU Leader:
Länsman, Anni-Siiri

Professors:
Lehtola, Veli-Pekka - Ylikoski,
Jussi Mika Petteri

Other PIs:

Academic Staff in 2019	14
Professors	2
Senior Researchers	5
Postdoctoral Researchers	1
Doctoral Students	5
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	2
Docents (Adjunct Professors)	3

General description of the RU

The Giellagas Institute for Saami Studies has nation-wide responsibility for organizing, introducing, and providing Saami language and cultural studies and research at the academic level. The Giellagas Institute has a remarkable societal task to revitalize Saami languages and cultures. This also means following the sociocultural developments among the Saami people, i.e., the issues leading to language and culture revitalization. The institute hosts the Saami Culture Archive, which constitutes a significant source of linguistic and cultural knowledge and resources for academic research in Saami language, cultural, and sociological studies as well as teaching and Saami cultural work.

Current description of the RU (rating 5)

Current research performance: The institute is to maintain and support Saami cultural and linguistic heritage, and to contribute to the vitality of this heritage and its future development. Given its small size and wide tasks, its research performance needs to be evaluated in terms of how it contributes to supporting the Saami community on the academic level, and whether it succeeds in transmitting the results of this research into the community. The impact it has on Saami studies is unique in Finland and strong in the field of Saami studies at large. The width of topics covered is impressive. It has established a tradition of Saami research, including the teaching of students and the supervision of PhD projects, which had not existed before. The members of the institute publish widely, and in many languages, but Saami and Finnish dominate, as is appropriate given its tasks. The output of peer-reviewed journal articles has nevertheless significantly increased over the last years. The senior staff are very active in their fields, have impressive publication records, and are highly acknowledged and influential scholars in their respective fields. The societal impact of its research and education is very high, both in Saami communities and in the Finnish society.

Research environment: The institute is an attractive research environment, as evidenced by a high number of current PhD students. Collaboration within the institute seems tight-knit, particularly between senior and junior members. The institute is very active in academic cooperation in Finland and Northern Europe. The Saami Cultural Archive at the institute plays an essential and ever-increasing role for research, in addition to its documentary purposes.

Future potential of the RU (rating 4)

Future research potential and impact:

The institute plans on fostering education and research on Skolt Saami, making Saami research more visible nationally and internationally and developing Saami "scientific tools", that is digital resources. These goals are highly relevant, and societally important.

Research environment:

The institute faces challenges in terms of personnel and financial resources needed to achieve the goals of the Scientific Action Plan. The lack of potential research recruits and the problems with recruitment of top-level established researchers makes the attainment of the future targets demanding. Particular attention needs to be directed to the funding of doctoral students and recruitment of researchers, in order to ensure the viability of the institute as a research unit also in the future.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights

- Responsibility to carry out research on the language and culture of the Saami
- Education and training of next generation of Saami researchers
- Width of topics in research and teaching
- High scholarly impact
- Societal relevance
- Saami Cultural Archive

Strengths:

- Successful maintenance of Saami cultural and linguistic heritage and revitalization of the Saami languages
- Close collaboration with non-academic institutions in the Saami community
- Implementation of complementary Saami Language Education
- Training of next generation of Saami researchers
- Highly influential research in Saami cultural studies (history), linguistics and applied linguistics
- Saami Culture Archive and other documentation and archive functions

Development areas:

- Recruitment strategy
- Personnel and financial resources

Recommendations

The institute should develop a recruitment strategy at both junior (PhD/Postdoc) and senior levels.

The institute should aim at developing a roadmap for the future development of the Saami Cultural Archive, not only technologically but also with respect to the data types included and the data to be collected in the future.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

History, Culture and Communication Studies (HistCulComm), Faculty of Humanities
RAE2020 code: CS 04

RU Leader:
Alenius, Kari

Professors:
Alenius, Kari – Heikkinen, Hannu I. – Herva, Vesa-Pekka – Huotari, Maija-Leena – Karvonen, Erkki – Kinnunen, Tiina – Kuukkanen, Jouni-Matti – Pietikäinen, Petteri

Other PIs:
Lipkin, Sanna – Salmi, Anna-Kaisa – Hokkanen, Markku – Ikäheimo, Janne – Okkonen, Jari – Ylimaunu, Timo – Hakosalo, Heini – Niskanen, Markku – Kallio-Seppä, Titta

Academic Staff in 2019	81
Professors	8
Senior Researchers	28
Postdoctoral Researchers	18
Doctoral Students	27
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	17
Docents (Adjunct Professors)	16

General description of the RU

The RU combines the expertise of archaeology, cultural anthropology, information studies, history as well as the history of sciences and ideas. These disciplines provide Master Programmes and function as major subjects for students in the faculty. Within the RU, there are several research groups with different topics and objectives, yet united in their focus on issues related to health, well-being and environment (see Scientific Action Plan).

Current description of the RU (rating 5)

Current research performance: Overall, the unit delivers excellent work in terms of methodology, empirical materials and theoretical issues, and the RU's impact on the scientific development of its fields is truly high in a substantial rather than measurable sense. The thematically wide-ranging disciplinary and multidisciplinary research at the unit is in many ways creative and original. Some of it, e.g., in the fields of history of science and ideas, and history of health and medicine, has a high international scholarly impact. In general, the RU enables valuable, individual, single-authored endeavours and fruitful collaborations. The unit publishes high quality research internationally and nationally. Its members are widely influential and sought-after as research collaborators, in Finland and internationally. Members of the RU are highly active participants in national and international research collaboration. Many aspects of the RU research have societal relevance and gain wide national and local audiences. The range of societal impact is truly broad.

Research environment: The RU has obtained an impressive amount of competitive research funding. It provides a fruitful environment for PhD students. Due to RU field diversity, collaborations are with different partners, and this secures a very rich and broad spectrum of collaborative endeavours with relevant and appropriate partners. There are some important collaborative efforts between RU members, and internal collaboration enhances the quality of research by establishing multidisciplinary platforms. Open seminars facilitate cross-disciplinary exchange of ideas and the academic connections that create new scholarly frameworks for formulating new research questions.

Future potential of the RU (rating 5)

Future research potential and impact: The RU has properly ambitious yet realistic plans for future research. Several research strands, particularly highlighting an Arctic dimension, are identified, all of which are well aligned with the University profiling arenas. The proposed research strands are all societally relevant and, if successful, likely to produce significant new outcomes in academic terms, further strengthening the RUs national and international standing and impact. The development targets are largely dependent on successful attainment of external funding, an area where the RU has had great success earlier.

The current research environment is supportive of the future plans. Depending on the success in obtaining funding, the planned centres of excellence will further enrich the research environment. The viability of the Scientific Action Plan is also dependent on the success of the RU in enhancing collaboration within the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights

- Numerous internationally influential publications

- Highly valued research partners, in Finland and abroad

- Research outreach in Finland

- Leading research milieus in several areas (e.g., Centre for Philosophical Studies of History)

- A good environment for young researchers (PhD candidates)

Strengths:

- Highly competent staff

- Very productive researchers

- High academic and societal impact, nationally but also internationally

- Ambitious future plans

Development areas:

- Balancing research time and teaching load

- International visibility of research

- More theoretical, critical-reflective, normative and classical humanities aspects or strands

- The role of the Centre for Philosophical Studies of History

- Research leadership structure

- Internal research collaboration

Recommendations

The RU should strengthen its internal collaborative efforts

The RU should revise and clarify its research leadership structure

The RU might rethink the overarching theme that is to encompass future research strands

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Kerttu Saalasti Institute (KSI), Regional Unit

RAE2020 code: CS 05

Primary panel: Culture and Society
Secondary panel: Natural Sciences and Engineering

RU Leader:
Muhos, Matti

Professors:
Muhos, Matti

Other PIs:
Järvenpää, Antti – Kotavaara, Ossi – Simunaniemi, Anna-Mari

Academic Staff in 2019	42
Professors	1
Senior Researchers	4
Postdoctoral Researchers	16
Doctoral Students	21
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	1

General description of the RU

The University of Oulu, Kerttu Saalasti Institute is an international research institute with a mission to provide evidence-based knowledge on micro-sized enterprises and their operating conditions. Our research theme is Operational Excellence of Micro-Enterprises. The Kerttu Saalasti Institute provides knowledge from the perspectives of Micro-Entrepreneurship as well as Future Manufacturing Technologies and Regional Excellence that enable vitality and growth at the micro-enterprise level. University of Oulu, Kerttu Saalasti Institute being the responsible RU, was appointed a new national task by the Ministry of Education starting in 2021: Micro-entrepreneurship Education and Research. Since the beginning of 2020, the institute is responsible for the research-based micro-entrepreneurship online education at our university. Kerttu Saalasti Institute is the only research institute in Finland and internationally that focuses on micro-enterprises. Societal impact of research is our strength.

Current description of the RU (rating 5) Current description of the RU (rating 5)

Current research performance and research environment:

The KSI has a competitive publication strategy. The publishing venues of the KSI are selected systematically to ensure continuously increasing quality and quantity of the publications. The selection of the publication venues is based on international impact factors (Journal Citation Reports JRC and Scopus) and national classification of publication venues (Publication Forum). The KSI lists the target publication venues based on focus of the publishing venue, scientific quality, impact, and open science practices.

The RU has a sound academic culture and strong research leadership. The quality and quantity of publications is monitored monthly in the KSI management group. The minimum publication target set for the research groups is two publications at Publication Forum Levels 1-3 per researcher per year (3 = highest level). Research directors monitor the development of publishing activities at the group and individual level.

Future potential of the RU (rating 5)

Future research potential and impact:

The RU has an ambitious research strategy to further increase quality and number of peer-reviewed scientific publications and at the same time stay relevant for businesses and society.

For KSI FMT, the aim is to establish a unique research environment that is competitive in worldwide comparison. They appear already quite near the objective with induction heating. For KSI Rex, the ambition is to contribute to audiences of particular disciplines, to developers and policy makers at regional, national

and EU-level and to the general public. All three research units have clear ambitions and innovative ideas for the future. Furthermore, they address areas that are of societiel importance and it is likely that all research units will produce novel evidence-based findings.

KSI's research areas fit well into University of Oulu's strategy with focus on among other things sustainable solutions to societies' challenges.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights of major scientific achievements:

- The publications have been rising sharply as a result of systematic improvement of the KSI publication process.

- The RU has developed extensive international/global/national research collaborations which when combined with its long-standing and widespread network of non-university collaborators (e.g., private companies and public organizations) make this unit standout from the crowd. The participation and engagement the unit works into its research agenda is very impressive.

- The RU has a strong focus on its societal impact and this is central to its ethos

- They have developed a policy of actively dissemination and popularization of their research findings.

Strengths:

- The RU has a competitive publication strategy resulting in a strong focus on high quality outputs.

- The recent consolidation and change in focus of the RU to microenterprises

- Strong research leadership where quality and quantity of publications is monitored monthly (as noted above)

- The RU's nearness to business and society

- The RU's dissemination and popularization of its research (as noted above)

Development areas:

- The research unit appears 'slim at the top'. We would suspect that more senior researchers and professors are needed to carry out the strategy.

- It is important that post-docs and doctoral students have a trustworthy and realistic career path at KSI. If the chances of becoming a senior researcher and eventually professor are very small it may reduce the chances of developing KSI to the next level.
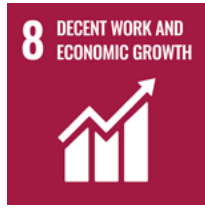
The self-evaluation report raises a concern that more time could be used for research leadership than managerial matters. It's an issue that should be addressed.

Recommendations

We recommend that the RU builds on its current research strategy, which has served so well in recent years. This implies that the RU

- Maintains and refines its ambitious research strategy

- Focuses on microenterprises

- Maintains and develops its international/global/national research collaborations

- Maintains closely related with businesses and society

- Develops its external funding allowing for further initiatives and faculty

- Addresses 'development areas' listed above

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

1 NO POVERTY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

Languages and Literature (LangLit), Faculty of Humanities
RAE2020 code: CS 06

RU Leader:
Haddington, Pentti

Professors:
Haddington, Pentti – Kärkkäinen, Elise – Keisanen, Tiina – Korhonen, Kuisma – Rossi, Paula – Sivonen, Jari

Other PIs:
Frick, Maria – Kunnas, Niina – Kuure, Leena – Ojajärvi, Jussi – Oloff, Florence – Rauniomaa, Mirka – Sandberg, Eric

Academic Staff in 2019	63
Professors	6
Senior Researchers	20
Postdoctoral Researchers	8
Doctoral Students	11
Researchers on Personal Grant	8
In Teaching only	9
Of these:	
Principal Investigators	11
Docents (Adjunct Professors)	13

General description of the RU

The research in the Research Unit builds on diverse theories and approaches in language studies, literature and cultural studies. It studies social and cultural change in communication, hence aligning with the University of Oulu's research focus area "Understanding humans in change". It has a strong international profile in the research of language and meaning beyond the verbal through the concepts of 'multimodality' and 'intermediality'. The RU explores 1) processes of digitalisation in multimodal interactions and language learning, 2) social sustainability as an interactional and discursive phenomenon and 3) literary and cultural meaning-making processes emerging from complex relationships across media types. The research is theoretical and empirical and often relies on digital materials. It develops methodologies utilising newest technologies (e.g. 360° video, virtual reality, automatic speech recognition). Its research results are applied to the betterment of society; they contribute to the education of communication experts for northern Finland, the education of future teachers and training in various work-life contexts.

Current description of the RU (rating 5)

The following remarks are somewhat tentative as the full information necessary for assessing this rather large RU was not available (complete list of personnel, complete list of publications, internal structure of the RU with the disciplines involved, etc.).

LangLit has a clear research strategy which is outlined convincingly in the report. This strategy is to form clusters (multimodal studies in linguistics, multimediality in literary and cultural studies) and through successful recruitment, external project money and a skillful publication policy, bring these clusters to national or even world-wide recognition. Particularly in the multimodal linguistics group which has contributed in important and internationally acknowledged ways to the field of interaction analysis, using novel technologies and uncovering new fields of research, the strategy to form clusters has been highly successful.

The complementary field of multimedial cultural studies appears less profiled. In fact, it appears that research outside the multimodality cluster is more individualistic and less coherent. A question that we were not able to answer is whether and to which degree members of the institute who are not part of the clusters can pursue their research interests, given the fact that a wider range of specializations is necessary, if only in order to secure teaching of adequate breadth.

The 11 senior researchers whose CVs have been added to the report have a very strong output, a very impressive record and their Google Scholar h-index values are high (or in the case of non-available Google accounts, they are often cited in the community), considering their academic age and their topics/fields. These members of the RU have also been successful in gaining external "competed" money, and they have commendably achieved grants, distinctions, awards, collaborations (especially internal). The 20 top publications listed in the appendix are of high and highest quality. However, in bibliometric terms, and given the size of the RU and the number of researchers belonging to it, the publication output of the RU as a whole can and should be better, particularly the number of publications in English could be higher, without this entailing neglect of publishing in other languages or undermining the publication strategy of the unit.

The RU as a whole is truly aware of its public role and related potentialities. The unit has excellent interactions with society and its works have a remarkable societal impact of various kinds, extending, for example, to cooperation in the revitalization of minority languages of the indigenous populations in the Arctic. Another area with societal impact is the application of digital technologies to social problems and the training of language teachers.

Cooperation between the RU and the Faculty and the university seems to be running smoothly and efficiently, and the RU is actively involved in designing and implementing the university's profiling areas. The Eudaimonia Institute is of central relevance here.

Future potential of the RU (rating 6)

The self-evaluation report presents a thought-through concept and a clear vision of where the unit wishes to go. It unfolds its plan attentively and enthusiastically, taking into consideration the related UN sustainable development goals. In supporting research and publication in diverse languages and sources, the unit actively promotes the sustainability of this kind of diversity. The establishment of a thematic focus – "language and meaning beyond the verbal" – has already led to a successful restructuring of the RU in the past but will need additional efforts in the future in order for the RU to reach its ultimate aim of becoming "the leading research unit in multimodal and intermedial studies" in Finland (and perhaps one of the leading RUs of this kind in the world). Linking this focus area with processes of digitalisation seems particularly promising. The RU's strategy for the future is particularly innovative and promising in the context of the humanities and definitely has the potential of redesigning aspects of the roles of the humanities in a modern society. We are not able to say whether the costs involved in such a restructuration have also led to the neglect of areas of humanistic research which are usually considered to be central, due to lack of information.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights

We liked the way in which the RU strives for international visibility and has successfully established research foci which are innovative, technologically advanced, and which address core problems of (late) modern societies from a new angle. At the same time, the RU has strong ties with the local northern Finnish culture and its specific characteristics.

Strengths and development areas

The restructuration of the humanities around research foci is one of the strengths of the Unit. We can see its success, and we appreciate it, but understand that some research areas and disciplines may not be engaged sufficiently in this transformation. The self-evaluation report shows awareness of the need to "encourage and strengthen disciplines that are less active in research" in the RU. No doubt, this will be one of the challenges of the future.

Recommendations

Though the RU characterizes its international profile as strong, the representation of the unit's writings in international journals should corroborate this somewhat more strongly.

Though literature (and literary theory) are included in the range of the unit's research interests, the actual emphasis is on non-literary and more linguistic-oriented research themes. This should be considered and possibly revisited.

The unit's output is high-quality but the number of publications in English could be higher, without this entailing neglect of publishing in other languages or undermining the publication strategy of the unit. That is, the rate of publications in English could be steadier, less fluctuating, and should even increase.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Learning and Learning Processes (LLP), Faculty of Education
RAE2020 code: CS 07

RU Leader:
Järvelä, Sanna

Professors:
Järvelä, Sanna – Muukkonen-van der Meer, Hanni-Mari – Mäkitalo, Kati – Pyhältö, Kirsi

Other PIs:
Järvenoja, Hanna

Academic Staff in 2019	45
Professors	4
Senior Researchers	8
Postdoctoral Researchers	7
Doctoral Students	15
Researchers on Personal Grant	2
In Teaching only	9
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	5

General description of the RU

The Learning and Learning Processes Research Unit (LLP) tackles the following problem: How can we increase human learning competence for the 21st century needs? The unit's expertise lies in integrating theoretical perspectives on the social, cognitive, motivational, and emotional processes of learning in different learning contexts, here with a special emphasis on learning in groups. It employs multimodal methodological approaches toward research. The unit's five-year objectives are as follows: 1) Translate recent investigations on cognition, motivation, and emotions, here with a special emphasis on regulation of learning, to advance the theoretical and empirical understanding of individual and collaborative learning; 2) promote methodological development for process-oriented methods and learning analytics; 3) implement advanced technologies to support individual learning and create opportunities for collaboration and increased competence building among learners; and 4) ultimately develop solutions for learning support utilizing artificial intelligence affordances in multidisciplinary collaboration. Accordingly, LLP research has a scientific impact on learning research and solving future learning, competence building, and ongoing education challenges.

Current description of the RU (rating 6)

The RU's research in socially shared regulation in learning is very well known worldwide. In addition, they contribute significantly in adopting and developing learning analytics and advanced technologies for studying and supporting the learning process at both individual and group level. The RU has a good strategy to support publishing; it does not focus so much on quantity but on quality, relevance, and impact.

The staff members of the RU have been highly active both in international collaboration and on the national level. The focus has been on research grants awarded by the Finnish Academy and in the recent years they started to work more systematically in applying major international research grants as well. So far it has been not the strategic aim and; therefore, they have received only a minor funding on international level.

The RU has strong societal impact at national level through research for better skills for learning and collaboration; helping teachers understand student learning; designing models and methods for teaching and learning; and developing technological tools in support of learning. Less visible has been international societal impact and collaboration with non-academic partners.

The LLP has good established collaboration with several other units of the University of Oulu. The LeaF centre enabling multimodal data collection provides an excellent research environment for the LLP but also other RUs at the University of Oulu.

Future potential of the RU (rating 6)

The LLP RU has established clear and ambitious goals for the next years based on their work done earlier. The goals are internationally very relevant and realistic for the RU teams. There are also identified weaknesses of the RU and potential threats that need to be taken into account in implementing the strategy.

The plans of the RU are very realistic if the strong researchers of the RU could focus on research and if they could extend their research groups with additional research staff. Even more, if a few additional research groups could be established and all academic staff members could be involved in research activities. This calls to a need to discuss the issue of potential overload of the top-level researchers in LLP and how to fund LLP so that more staff members could be hired and their professional development could be well supported in short time. One strategic goal to achieve the goals should be more active international networking with the aim to establish strong consortia to apply for larger international research funds.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights

- Three research groups collaborating on learning sciences, educational psychology and educational technology have an impressive number of high quality publications; two of them among highly cited publications in Web of Science
- The research in socially shared regulation in learning is a break-through at the world level
- Very good success in applying for national Finnish Academy grants and high potential in securing international funds
- Strong research partners in different countries in Europe, North America, and Australia
- High quality research environment that could host several more researchers to extend the scientific and societal impact of the research groups at both national and international level even more

Strengths:

- Excellent quality and international impact of published work
- Very good strategy to support publishing and teaming up between junior and senior researchers
- Strong international network on what to build international research projects
- Clear view on how societal impact is achieved through research on learning and collaboration, helping teachers to understand learning and applying models and methods for teaching and learning, and developing technological tools for better learning
- High potential for interdisciplinary research using the LeaF infrastructure

Development areas:

- Internationally obtained competitive funding (e.g., EU level grants)
- More visible collaboration with international research partners and national non-academic partners
- Recruitment of more researchers, including additional professors
- Lessening of teaching and administrative workloads to make more time for research endeavours
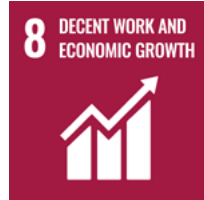
Recommendations

The RU should focus on the strategic goal to apply more international research funds they have defined only in the recent years. This could even more open their potential in international scientific and societal impact based on established collaborators. Even more, this would also contribute in professional development of the partners' research units.

The RU should consider establishing a strategy to recruit more researchers to the team, including post-doctoral researchers in all research groups. There is in the RU a very good strategy to support their scientific

competence in research and publishing but activities supporting their long-term mobility and engagement in international networks could be even more strengthened.

It is suggested to avoid fragmentation of the work between research, teaching and administrative tasks. The potential of the outstanding researchers should be less spent on other tasks than internationally and nationally highly impactful research.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

3 GOOD HEALTH AND WELL-BEING

4 QUALITY EDUCATION

5 GENDER EQUALITY

8 DECENT WORK AND ECONOMIC GROWTH

Logopedics (Logo), Faculty of Humanities
RAE2020 code: CS 08

RU Leader:
Kunnari, Sari

Professors:
Huttunen, Kerttu – Kunnari, Sari

Other PIs:
Loukusa, Soile – Välimaa, Taina – Yliherva, Anneli

Academic Staff in 2019	19
Professors	2
Senior Researchers	7
Postdoctoral Researchers	2
Doctoral Students	4
Researchers on Personal Grant	0
In Teaching only	4
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	5

General description of the RU

Multidisciplinary research conducted in the Research Unit of Logopedics (RULOGO) ranges from typical and disordered speech, language and communication development and functions to interventions and their efficacy. The RU uses experimental and descriptive methods, working with people of all ages, from new-borns to senior citizens, and with numbers of participants ranging from small focused samples to large cohorts. Multifaceted methodology is used in data collection and analyses encompassing behavioural, neural and physiological methods. RULOGO advances research by providing new knowledge on complex relations between language, cognition, bio-physiological phenomena and social-emotional behaviour. The RU's research on a sparsely studied agglutinative language and culture-specific features can affect existing and new theories on language acquisition and communication. The results provide significant information for efficacious interventions needed in clinical practice, promoting equality for persons with communication challenges.

Current description of the RU (rating 6)

RULOGO is a well-organised unit which carries out both fundamental and applied research in a very efficient and successful way. In terms of publications, PhD supervision (10 current PhD projects) and external funding (2,8 Mio € over 6 years), the RU is internationally competitive. RULOGO employs sound and relevant experimental and descriptive methods to contribute in a multi-/trans-disciplinary way to the production of knowledge and information that is conducive to improving clinical practice and advancing equality for people experiencing communication challenges. The number of publications of the group is high. Logo is indisputably productive and its publication output is impressive, particularly taking into account the small number of researchers and their additional duties besides research. At least the senior researchers whose CVs are included in the report are mostly of international standing and their work is internationally recognized. The 20 publications in the appendix have been published in high-ranking journals and edited volumes. The list of selected publications also mirrors the success of the unit in securing both the joined, collaborative efforts of its members and the opportunities of collaboration with other researchers from Finland and abroad. Academy of Finland grants and other national funding show how well-positioned and highly regarded their research is nationwide. Their international recognition by the global research community in the field of speech, language and communication sciences/therapy is evident from the numerous citations that the unit has if one adds up all the citations of its researchers' works.

The societal impact of the unit is indisputable and the unit serves it through all the standard channels or activities (collaborations, seminars, interventions in public sphere related debates, social media, etc).

The report shows a strong awareness that communication among the RU members is essential for its success, and many details suggest that this communication is very good. The intellectual climate in the unit appears to be truly conducive to research.

Future potential of the RU (rating 5)

The unit's targets develop further and deepen what the unit has already achieved. Logo's agenda shows a critical awareness of paths that the unit has not yet pursued but which promise new achievements. At a declarative-rhetorical level, the plans of Logo are sound. The related sections in the self-evaluation combine a clear sense of societal mission for a social justice agenda with an undiminished commitment to original research.

The list of five targets is, however, rather broad and general; this particularly applies to Target 1 ("move from exploring single linguistic phenomena toward understanding language and communication and their underlying processes") and Target 2 ("understand better the effects of societal changes challenging communication ability"). They are certainly feasible, but a more specific listing could perhaps have set the agenda in a more concrete and interesting way.

The report stresses the point that the number of senior researchers is too low, also given the amount of time that needs to be invested in PhD supervision and teaching. This may hamper the future development of the RU.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights

Internationally visible research unit which at the same time caters for the needs of the Finnish community and the local practitioners and clinics

High societal relevance

Good research output among most of the senior staff

Substantial external funds

High cohesion and internal cooperation

Strengths and development areas

The amount of international cooperation could be enhanced, and output in high-ranking international journals, although quite satisfactory, could still increase.

Recommendations

As our overall grading (6) already shows, we do not think that the RU needs major restructurations or strategic changes. We recommend to pursue ambitiously the present strategy, which consists of combining a strong international research output with an equally strong embedding in the northern Finnish logopedic community.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Martti Ahtisaari Institute (MAI), Oulu Business School

RAE2020 code: CS 09

Primary panel: Culture and Society
Secondary panel: Natural Sciences and Engineering

RU Leader:
Seppänen, Veikko

Professors:
Koivumäki, Timo – Seppänen, Veikko –
Pikkarainen, Minna

Other PIs:
Ahokangas, Petri

Academic Staff in 2019	13
Professors	3
Senior Researchers	2
Postdoctoral Researchers	2
Doctoral Students	3
Researchers on Personal Grant	3
In Teaching only	0
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	4

General description of the RU

Martti Ahtisaari Institute, established in 2008, is a research and education unit within Oulu Business School at the University of Oulu. The institute conducts research and development activities to create new knowledge on responsible business and global economy. We create, develop and help to deploy new research-based business knowledge by building on the knowledge, skills and competences of individuals, organizations and networks in the context of changing businesses, using scientific principles and methods. The Institute operates through research and development projects, executive education programs and degree education including, for example, a minor in entrepreneurship. We develop our education offerings to respond to the internal needs and external opportunities of our stakeholders. In addition, the institute arranges annually events that provide a forum for discussions and a platform for new insights into the development of the economy and business life.

Current description of the RU (rating 4)

The multidisciplinary nature of the RU makes it well-placed to undertake creative and original research. They benefit from addressing areas of current interests including digitally enabled and sustainable businesses in ecosystemic contexts. It is the multidisciplinary approach to this that is creative and innovative rather than the research area itself, nonetheless, the RU has produced some interesting outputs and a key aim is to develop new scientific communities in the area.

This is a very small multidisciplinary RU and the RU was only established in in 2008, thus the focus of the RU can – based on the description - be difficult to narrow down, which makes it a hard to position the research. Nonetheless, it is developing many relevant and important national and international collaborative relationships and has been successful in attracting research funding.

There is no doubt about the societal relevance and impact of the RU. They are addressing highly relevant topics such as business creation (e.g. Business Kitchen which is a joint new business incubating and development environment), business development in industrial and public organizations and knowledge creation. Members of the RU hold a number of important roles in industry on the boards of directors, act as parliamentary advisors and are involved in digital development communities.

Future potential of the RU (rating 4)

The RU seems to have a clear vision for its research and has defined three objectives. The three objectives of the RU are to explore and explain how do the dynamic new digital businesses influence individuals, businesses, ecosystems and the society as a whole (objective 1), what kind of value related processes drive scalable, replicable and sustainable digital businesses (objective 2), and how future scalable, replicable and sustainable digital businesses are renewed in unstructured and uncertain operational environments (objective 3).

The RU has ambitious research goals and objectives and publishing strategies, their second objective has potential (if achieved) to make a significant theoretical contribution to the management discipline. Their publishing ambitions may prove difficult to achieve given that they do not have a track record of publishing in the top-level journals, e.g., Strategic Management Journal, nor are they involved the academic groupings around these journals (e.g., Academy of Management).

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights

- The significant change in the RU's productivity
- The RU's focus on international visits and collaborations
- The societal relevance of the RU, specifically business creation and development, e.g. the Business Kitchen
- A collegiate and inclusive environment
- Plans for stabilizing their income

Strengths

- Societal relevance of the RU
- Good balance between Finnish and non-Finnish personnel
- International collaborative visits made and hosted
- Embedding of doctoral students in the unit
- Ambitious plans for the future

Development areas

- Focus on developing high quality publications
- Developing stability in the funding streams
- Becoming engaged in the relevant academic communities
- Ensuring that the future leadership of the unit is decided

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

No connection reported.

Department of Marketing, Management and International Business (MMI), Oulu Business School

RAE2020 code: CS 10

RU Leader:
Puhakka, Vesa

Professors:
Hurmelinna-Laukkanen, Pia – Juga, Jari – Mainela, Tuija – Nätti, Satu – Puhakka, Vesa – Tuunainen, Juha – Ulkuniemi, Pauliina

Other PIs:

Academic Staff in 2019	46
Professors	7
Senior Researchers	10
Postdoctoral Researchers	10
Doctoral Students	11
Researchers on Personal Grant	6
In Teaching only	2
Of these:	
Principal Investigators	7
Docents (Adjunct Professors)	9

General description of the RU

MMI is a multidisciplinary research unit of the University of Oulu Business School, advancing knowledge in business studies at the intersection of marketing, management, and international business. It aims to increase understanding of complex organizational activities by asking thought provoking questions and challenging the current views. The research tackles organizational dynamics related to technological development, globalization, challenges of democracy, and intergenerational differences aiming to contribute to solving important business and societal issues. Contextual and temporal explanations and revealing of the mechanisms of change are emphasized in the research. The main focus areas include brand building, international business & international entrepreneurship, open innovation & appropriation, purchasing behaviour, and service business. Significant research is on-going on change processes in science and education, public procurement of innovations, service design, start-ups, and high-growth companies, and strategy as practice.

Current description of the RU (rating 5)

The research (marketing, management, international business) at the RU is in many ways creative and original. This multidisciplinary RU combines research in a range of inter-related areas and uses these synergies very creatively to provide innovative contributions to these disciplines. The RU has a strong track record in the field of industrial marketing and the roots in industrial marketing research are still evident. Other researchers within RU have also made important contributions. Innovative angles are brought into this research field, particularly in international opportunity in entrepreneurship and innovation and focus on micro-firms. Work on the sharing economy is also important and indicates the success of the broadening focus of the RU. The RU includes leaders in their respective areas and all are active in national and international research collaborations.

The RU focuses its research on important aspects of business including employment and business success and ethical business issues.

The RU's research culture is built around collegiality, decisions and targets are arrived at through consultation and discussion; the environment is highly supportive and designed to encourage growth of all members of the RU. There is clear evidence of an environment that is built on and thrives on principles of mentorship.

Future potential of the RU (rating 6)

There is no doubt that the RU has ambitious scientific objectives and goals and also innovative ideas for the future; these are closely aligned with the university's goals and key research themes. It emphasises research in high ranked journals. Thus, there are reasons to expect the RU to increase the number of high quality publications in the future. The research focuses on areas of challenge faced by business and consumers and thus has significant potential to have impact on society and business.

Notwithstanding, the plans for realizing impact are impressive and appropriate, the notion providing impact through laboratories that allow interaction of researchers and students is novel and exciting because of its three-way impact.

The RU has a reasonable number of faculty members. Further, it has developed an ambitious research agenda and it is likely that RU will meet its ambitious research goals. More external research funding will make the realisation of the RU's research goals even more realistic.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights

- Innovative nature of the research
- New focus on publishing in higher level journals
- Wide-reaching international collaborations
- Making societal impact of its research more explicit
- Collegiate, highly-supportive working environment
- Research-led/informed teaching ethos

Strengths

- Ability to broaden the focus of the RU in new and innovative directions
- Strong collaborative research relationships
- Good links with local businesses
- Focus on mentorship
- Clear progression path

Development areas

- Ensuring publication goals are met
- Maximizing the impact of research nationally as well as locally
- Ensuring enough human capital is made available to support the RU's research plan.

Recommendations

- Maintain the focus on the new publication targets
- Focus on local business links to ensure research insight is put into practice
- Use mentorship to help support the publication strategy
- Balancing teaching and research demands
- Considering alternative ways of disseminating research to practitioners

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Teachers, Teaching and Educational Communities (TTEC), Faculty of Education
RAE2020 code: CS 11

RU Leader:
Ylitapio-Mäntylä, Outi

Professors:
Kaasila, Raimo – Ketovuori, Mikko – Puroila, Anna-Maija – Takala, Marjatta

Other PIs:
Lanas, Maija-Liisa – Rautio, Pauliina

Academic Staff in 2019	65
Professors	4
Senior Researchers	14
Postdoctoral Researchers	7
Doctoral Students	23
Researchers on Personal Grant	0
In Teaching only	17
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	9

General description of the RU

Teachers, Teaching and Educational Communities (TTEC) is, by number of staff members, the largest unit of the Faculty of Education, University of Oulu. It includes the research communities Living Relations (LR) and Special Education (SpEdu). Research and teaching are intertwined in the work done in the TTEC. In the unit's multi-disciplinary research, education is considered a relational phenomenon, and thereby TTEC addresses multiple relations in educational communities. Its work focuses on the areas of teacher and childhood research and relationality, identity, emotions and values in educational communities. TTEC has received international recognition as it has reached scientific impact in these research areas, both theoretically and methodologically. Its work also has a societal impact due to its involvement of participants in research, utilization of multiple channels to share research knowledge and influence on educational policy and decision-making. Further, TTEC is responsible for educating future professionals in various educational fields, from early childhood education to higher education. It provides education for around 400 new teacher students each year, totaling around 2000 students.

Current description of the RU (rating 4)

The research of the TTEC RU is intertwined with teaching. This unit is responsible in educating future professionals starting from early childhood education up to higher education. The number of students thought is extraordinary and it might be understood that it allows focusing less on research. The research topic seem to be a bit broad and general, which reduces the possibility to identify the RU's special focus in the international context. A promising candidate for a speciality might be use of narrative methodologies, including discursive, ethnographic, and post-qualitative approaches on what they have started to focus recently.

TTEC has improved the theoretical understanding of education as a relational phenomenon, and emotions in teachers' work by illustrating the intertwinement of emotions and the micropolitical practices of work organizations.

The publication strategy of RU is too general. International publishing should be encouraged more clearly. In addition, concrete activities are needed to free teaching staff time to focus on research. There are supported academic writing groups and peer support is a good practice but at the strategic level might be more needed to advance the research of TTEC.

Between 2018 and 2020 TTEC researchers published 62 articles indexed in Scopus. It is still quite low number keeping in mind that TTEC has 65 staff members. However, there is a positive trend towards higher number of high quality publications. The 15 most active researchers had about 1000 new citations in Scopus from 2018–2020. This is showing more than 100 percent of increase for most of these researchers.

The RU has significant impact on educational policies at the national level, changes in teacher education, contribution to the development of educational practices, and development of educators' and children's well-being in collaboration with practitioners.

TTEC has only a small share of research funding in their budget. There is some national funding but very limited international funding. It is not sufficient to implement effective strategies to increase focus on research.

The research-teaching nexus has been understood as a key component of academic' identity of TTEC's staff members. However, the focus of most of the staff members seems to be on teaching rather than research. This shows an unbalance between research and teaching and it reduces sustainability of TTEC and might be in long-term a threat to the quality of teaching.

Future potential of the RU (rating 5)

The strategic vision of TTEC is a bit generic and does not specify the more focused topics where they could achieve excellence at international level. Their goals to ensure more research funding, stronger international networks, higher quality and volume of publications, and strengthening quality of researcher training are very relevant to build even better environment to open the scientific potential of the RU at the international level.

The action plan of the RU is developed around research projects already funded or the ones planned to apply in near future. This covers well the subject-specific goals but clear actions regarding all five strategic goals should be specified more clearly. New professors are needed to strengthen the RU's future potential. TTEC has a good plan to establish positions of research-teachers who are focusing on both – research and teaching.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights

- TTEC is the largest RU of the Faculty of Education with 65 academic staff members
- The RU has a very important societal impact at the national and local level
- In 2020 the RU succeeded to get funds for two Finnish Academy projects
- The researchers of the RU have several outstanding international partners
- The publication record and impact of the research of TTEC has significantly increased during the ecent years

Strengths:

- There are several strong researchers within the staff of TTEC
- The TTEC's research have strong societal impact through their teaching in teacher education studies and national collaboration
- The recruitment of new staff members is based on openness, transparency, and merit-based selection
- Several researchers in TTEC have very good international network with high potential of publishing high quality impactful articles and applying successfully for major international grants

Development areas:

- A more systematic approach for achieving greater stability in research funding is needed; there is a need to increase international funding, especially EU funding
- The impact of the publications according to the international metrics (e.g. Google Scholar citations) could be much higher
- The researchers in TTEC need to have more time to focus on research and the staff members focusing mainly on teaching should be step-by-step involved in the research teams around the topics they are teaching

- Opportunities for professional career development through international mobilities need to be more strategically planned

- Creativity and originality of the research of TTEC could be significantly higher

- The potential of the collaboration with several very strong international partners in different areas of the research groups should be more strategically and systematically used

Recommendations

Rather than focusing on more traditional studies on early childhood education, childhood studies, special education, teacher education and higher education in broad there is a lot of potential in new methods and not so well established areas of studies, e.g. narrative methodologies, inclusion and marginalization in contemporary more diverse settings, virtual learning and simulations in teacher education.

High quality research and career development in the RU should be supported more strategically by planning collaboration with several strong internationally outstanding partners the research groups of the RU already have, e.g. through publishing cutting-edge joint articles and applying for international research grants that provide resources to recruit more researchers and to build stronger networks at international level.

Participation and publishing in high quality conferences might be considered as a first strategic step for many TTEC staff members to focus more on research; however, the more established researchers should be supported to publish in the top level international and national journals and these should be recognized at the university level and national level even if these are not valued as the most impactful journals in the JUFO categories. National and international impact should be considered as two separate goals with different strategies and indicators of success.

Teaming up between different staff members should be more encouraged; e.g. teaching oriented and research oriented staff members, or junior and more established researchers. More focus should be set on recruiting doctoral and post-doctoral researchers.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Values, Ideologies and Social Contexts of Education (VISE), Faculty of Education
RAE2020 code: CS 12

RU Leader:
Puuronen, Vesa (in 2019) - Holma, Katariina (at present)

Professors:
Hintsanen, Mirka – Holma, Katariina – Lehtomäki, Elina – Puuronen, Vesa

Other PIs:
Huuki, Tuija – Alanko, Anu – Sunnari, Vappu – Ulvinen, Veli-Matti – Suorsa, Teemu

Academic Staff in 2019	36
Professors	4
Senior Researchers	13
Postdoctoral Researchers	8
Doctoral Students	9
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	9
Docents (Adjunct Professors)	not reported

General description of the RU

The VISE (Values, Ideologies and Social Contexts of Education) RU contributes to "Understanding humans in change", one of the focus areas of the University of Oulu. VISE consists of six research groups with strong national and international networks. The RU's research focuses on the following topics: citizenship and schools in transformation in the global and digital era, sustainable change and responsibility in everyday interaction, co-creation and knowledge production, ethical intercultural collaboration and research-based (teacher) education, immigration, integration and racism, multi-professional collaboration in pupil welfare work, personality, emotions (especially compassion), responsible social and educational policies and well-being. These topics are highly relevant from the perspective of science and society. The RU's research addresses current burning questions that all societies suffer from; the lack of trust in science, the legitimacy deficit of political systems, growing inequality and racism.

Current description of the RU (rating 6)

The VISE RU advances a highly original and topical research agenda of indisputable international and regional significance around the axes of psychology, sociology and philosophy of education. Several researchers of VISE focus on interesting and innovative topics and many cutting-edge research problems, which have significant societal and theoretical impact on the local culture and the international academic community correspondingly. All VISE contributions, theoretical and empirical, constitute in their own distinctive disciplinary way, a dynamic intervention in related international scientific debates and investigations.

Collaboration within the University of Oulu and the Faculty of Education seems to be based on individuals' research interests and needs more systematic and strategic handling to strengthen research in the focus areas of VISE in collaboration with researchers of other disciplines (by designing mutually valuable interdisciplinary research), yet always with an eye to securing that field-specific emphases on single-author scientific excellence will not be negatively affected. The academic leadership and the research environment generally reflect a collegial spirit and a commitment to advancing research, but signs of a negative effect of the structural reform started in 2016 at the university level are identifiable when higher workload on administrative duties results in less time for research.

Future potential of the RU (rating 5)

The VISE RU highlights the importance of multidisciplinary research and collaboration of researchers from all research groups. It is very sensible and in line with the evaluation of the strengths, weaknesses and challenges identified in the self-evaluation report. It is also a merit that the future scientific action plan, in its diversifications, puts forward an apposite and viable research agenda that takes fully into consideration its societal impact, further development of scientific excellence, and the UN Sustainable Development goals, and is committed actively to serving them. VISE's current growing tendency and the research that has been produced since 2016 indicates that the plan is feasible, subject to some caution and attention to the following concerns: limiting factors in applying the strategy such as external funds and long-term contracts; somewhat contradictory stances toward internal collaborations and their status in the RU; risks related to the emphasis on subject-specific goals obfuscating the significance of creating new opportunities for new scholars and for further international collaborations.

Overall, and apart from the above cautionary remarks, the future research potential is high and the current course to materializing it is appropriately aspirational; the current research scientific impact and achievements match, and justify, these aspirations; the future planning is generally both feasible and viable; and the university has largely been supportive (though the issue of increased expectations of administrative tasks from researchers constitutes a problem beyond the purview and the control of the unit itself).

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights

- Thematic diversity and a good combination and symbiosis of theoretical and empirical educational-philosophical, psychological and social sensibilities
- Impressive number of internationally influential and/or high quality publications in all fields
- U-Oulu top 1% position among institutions in psychiatry/psychology category;
- Based on global metrics and indicators, papers published by specific RU members in the period 2010-2020 have an average citation rate that is above the world average
- Quality-wise and field-specifically (e.g., philosophy of education), important intervention, contribution and recognition of research principal leaders worldwide

Strengths:

- Excellent quality of internationally published works of all the fields that the RU hosts
- Topics and issues of high societal, local and international, relevance
- Dynamic intervention in field-specific international scientific debates and investigations
- International collaborations with high academic level research partners
- Uniformity or one-size-fits-all standardizations are commendably avoided
- A good to outstanding (depending on field) number of memberships in nationwide and international scholarly associations
- Pertinent encouragement also of local outreach of research
- Good research-teaching linkages by encouraging students' research participation even at undergraduate level

Development areas:

- Internal research collaboration
- Internationally obtained funding/competitive funding (e.g., EU level grants)
- Recruitment of more researchers
- Lessening of teaching workloads to make more time for research endeavours
- Sharpening the future scientific action plan strategies

Recommendations

The RU should avoid a potential risk of fragmented structure and disciplinary isolationism. It should explore the possibility of benefiting from establishing multidisciplinary research topics based on the expertise in different research groups. At the same time, it should also avoid reaching the other extreme, that is, the effacement of field-specific particularities for the sake of multidisciplinary collaboration.

The RU should then continue, and possibly, intensify, its efforts to hit the mean and strike the right balance concerning the positioning, multidisciplinarity and collaborations of the diverse research fields that it hosts.

The RU should consider whether there is still margin in some fields/strands for increasing the quantity of research and the systematic work towards more impactful publications and towards making its international collaborations be better reflected in results.

The RU should consider whether, in the situation of shortage of funds, another feasible strategy might be to merge some groups that study topics that could easily be linked with one another.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

4.2.2. Summary report of the CS Panel

Overall assessment

The panel Culture and Society (CS) comprises a variety of units that engage with research on important topics in humanities and the social sciences, and they often do so on multidisciplinary grounds. Its RUs range across a wide spectrum of fields and disciplines, e.g., from Educational Studies to Geography and Linguistics. CS involves research departments and institutes, professors and young researchers, as well as strands and clusters of research. CS' members also have teaching and administrative duties, while their research covers theoretical and practical issues. The research output is aired both in academic and in social venues, in English and in Finnish (and occasionally in other languages), which proves the practical intent of the panel and its well-measured emphasis on both its scientific and its societal impact. CS shows great awareness of obligations toward the Finnish society that emerge from its primarily being a publicly funded institution.

CS research groups have varying foci and objectives, yet they are united in their commitment to a clear research strategy. They target high-quality international peer-reviewed journals, make critical and compelling contributions to important fields of study and publish high quality research internationally and nationally. Many CS members are widely influential and sought-after as research collaborators, in Finland and abroad. Most are also highly active participants in national and international research initiatives. Many aspects of the RU research have a major societal relevance (some regionally very strong such as the arctic emphasis) and even those whose relevance is not so direct are theoretically very significant and topical in the world of today. The produced research has a truly broad range of influence and increasingly gains ever wider national and local audiences. CS's scientific impact is multidimensional and impressive in a substantial rather than strictly or exclusively measurable sense.

Overall, the research conducted within CS is excellent, empirically and theoretically, and aligns both with the University's strategic goals and with the UN sustainable development goals. CS has a strong research leadership and a sound academic culture, supportive of the investigative spirit and conducive to collaboration. There have been many successful research funding bids, especially through Academy of Finland applications. As for future development, as a total, the CS contains ambitious yet also realistic and feasible scientific action plans the proposed research of which promises, if successful, to produce significant new outcomes and further to strengthen the CS's national, regional and international standing and intervention.

Strengths and development areas

Strengths

- Researchers are hard-working, striving to create an internationally respected, distinguished and energetic research environment with a broad scope of local and global influence.

- Many CS members are prominent in their field and highly influential. Most members are engaged in multiple collaborat

- CS's RUs have a research strategy that is oriented to publishing in high-quality international peer-reviewed journals. There where output is not high (or not top Jufo level) RUs show awareness of the need to strengthen it. The output in peer-reviewed journal articles has, over recent years, increased significantly.

- CS combines a clear sense of societal mission for a social justice agenda with an undiminished concern for original research.

- There is a generally supportive and friendly environment and infrastructures/facilities designed to encourage growth of all members of the RU. The intellectual climate in the CS units appears to be conducive to research.

- CS ambitiously pursues its present strategy and is committed to refining it in the future, always with an eye to strong intervention in international research and to strong contribution to the northern Finnish community.

Development areas

- There is a need for increased staff in some RUs.

- Several challenges in terms of personnel and financial resources have been noted.

- More theoretical, critical-reflective, normative and classical humanities aspects or strands seem to be missing or not adequately catered for.

- Internationally obtained competitive funding (e.g., EU level grants) should increase (wherever applicable).

- Institutionally, measures could be taken to lessen the workload that is not research-related (wherever applicable).

- More experienced, senior researchers and professors are needed in some RUs. In some cases, the number of researchers is too low, given the amount of time that needs to be invested in PhD supervision and teaching. This may hamper the future development of corresponding RUs.

Good practices and recommendations

Good practices

- CS already has a strong focus on high quality outputs. It addresses research questions with high societal significance and impact and does not neglect the development of local culture, language and society.

- There are good linkages of graduate studies and research that secure a smooth and integrative passage from studying to researching.

- There are well-established links with society and local culture, and a robust practical intent is evident throughout CS. Most evaluators noticed and praised the systematically and consistently cultivated ethos of societal relevance and contribution.

- All RUs members routinely apply for and receive national and international funding for their research.

- Due to CS field diversity, collaborations are with different partners, and this secures a very rich and broad spectrum of co-operative endeavours with relevant and appropriate partners.

- Open seminars facilitate cross-disciplinary exchange of ideas; multiple co-operations enhance the academic connections that create new scholarly frameworks for formulating new research questions.

Recommendations

- CS should maintain and develop its ambitious research strategies and its good balancing of scientific and societal goals.

- The career and experiences of students/faculty could become more internationalized.

- Researchers should be encouraged to broaden their publishing scope by trying not only strictly field-related journals but also interdisciplinary ones (wherever applicable).

- The staff should institutionally be given the time and space to work on their research by the university's lessening of teaching and administrative load (where appropriate).

- Though the CS disciplinary and multidisciplinary research is thematically wide-ranging, creative and original, there is still ample space: for more critical and cutting-edge rather than modish and conventional themes of research in some RUs; and for cultivation of more research fields in humanities that are not yet served (or not adequately) by the current research strands of the CS.

4.3. Natural Sciences and Engineering (NSE) Panel

Panel members:

Professor **Angelika Brückner-Foit** (Panel Chair), University of Kassel, Germany - Professor **Chris Bowen**, University of Bath, UK - Professor **Yvonne Dittrich**, IT-University of Copenhagen, Denmark - Professor **Alain Dufresne**, Université Grenoble Alpes, France - Professor **Robert von Fáy-Siebenbürgen**, University of Sheffield, UK - Professor **Viktor Krozer**, Johann Wolfgang Goethe-Universität, Germany - Professor **Günter Leugering**, University of Erlangen-Nürnberg, Germany - Professor **Jeppe Olsen**, University of Aarhus, Denmark - Professor **Ana Isabel Pérez-Neira**, Universitat Politecnica de Cataluña, Spain - Director **Catherine Pinel**, Univesité Claude Bernard Lyon 1, France - Professor **Ulrich Schollwöck**, University of Munich, Germany - Professor **Sabrina Schneider**, University of Kassel, Germany

Research Fields of Panel for Natural Sciences and Engineering:

energy technology – physics- geosciences and physical geography – chemistry - mechanical engineering and manufacturing technology - medical engineering - mathematics and statistics - materials science and engineering - process and chemical engineering - construction and municipal engineering, architecture - electrical engineering and electronics (incl. communications and automation engineering) - computer sciences, information technology – astronomy - biotechnology, bioinformatics and environmental technology related to the above fields other research into the natural sciences and engineering, including multidisciplinary research

Assessment results:

RESEARCH UNIT (RU)	Scientific quality and impact of the research	Societal impact of the research	Quality of the research environment	Future potential	OVERALL ASSESSMENT
ACM - Applied and Computational Mathematics	Very good	Good	Good	Good	Good
BIGS - Biomimetics and Intelligent Systems	Very good	Excellent	Excellent	Good	Very good
CAS - Circuits and Systems	Excellent	Excellent	Excellent	Very good	Excellent
CMVS - Center for Machine Vision and Signal Analysis	Excellent	Excellent	Excellent	Excellent	Excellent
CPE - Chemical Process Engineering	Good	Good	Good	Good	Good
CWC- NS - CWC-Networks and Systems	Excellent	Very good	Excellent	Very good	Excellent
CWC-RT - CWC-Radio Technologies	Outstanding	Outstanding	Outstanding	Outstanding	Outstanding
ECE - Environmental and Chemical Engineering	Very good	Good	Very good	Excellent	Excellent
FPE - Fibre and Particle Engineering	Very good	Excellent	Excellent	Excellent	Excellent
IEM - Industrial Engineering and Management	Excellent	Excellent	Very good	Excellent	Excellent
IMS - Intelligent Machines and Systems	Very good	Excellent	Very good	Excellent	Very good
INTERACT - Human Computer Interaction and Human-Centered Development	Very good	Very good	Excellent	Excellent	Excellent

RESEARCH UNIT (RU)	Scientific quality and impact of the research	Societal impact of the research	Quality of the research environment	Future potential	OVERALL ASSESSMENT
KUC - Kajaani University Consortium	Very good	Outstanding	Excellent	Excellent	Excellent
M3S - Empirical Software Engineering in Software, Systems and Services	Outstanding	Outstanding	Outstanding	Excellent	Outstanding
MathSci - Mathematical Sciences	Excellent	Very good	Excellent	Very good	Excellent
Met - Process Metallurgy	Outstanding	Excellent	Excellent	Outstanding	Outstanding
MIC - Microelectronics	Outstanding	Excellent	Outstanding	Outstanding	Outstanding
MME - Materials and Mechanical Engineering	Very good	Excellent	Excellent	Excellent	Excellent
NANOMO - Nano and Molecular Systems Research Unit	Very good	Excellent	Excellent	Excellent	Excellent
NMR - NMR Research Unit	Excellent	Excellent	Excellent	Outstanding	Outstanding
OASIS - Oulu Advanced Research on Service and Information Systems	Very good	Excellent	Excellent	Very good	Excellent
OMS - Oulu Mining School	Excellent	Excellent	Excellent	Excellent	Excellent
OPEM - Opto-Electronics and Measurement Techniques	Excellent	Excellent	Excellent	Very good	Very good
OSA - Oulu School of Architecture	Very good	Excellent	Very good	Very good	Very good
SCT - Structures and Construction Technology	Fair	Good	Fair	Good	Good
SGO - Sodankylä Geophysical Observatory	Excellent	Excellent	Very good	Very good	Excellent
SpaceAstro - Space Physics and Astronomy	Outstanding	Excellent	Outstanding	Excellent	Outstanding
SusChem - Sustainable Chemistry	Good	Very good	Very good	Very good	Very good
UBICOMP - Center for Ubiquitous Computing	Outstanding	Outstanding	Outstanding	Outstanding	Outstanding
WE3 - Water, Energy and Environmental Engineering	Very good	Excellent	Excellent	Excellent	Excellent

4.3.1. Research Unit evaluation reports of the NSE Panel (30 Research Units)

Applied and Computational Mathematics (ACM), Faculty of Information Technology and Electrical Engineering
RAE2020 code: NSE 01

RU Leader:
Ruotsalainen, Keijo

Professors:
Huhtanen, Marko – Ruotsalainen, Keijo

Other PIs:

Academic Staff in 2019	9
Professors	2
Senior Researchers	3
Postdoctoral Researchers	1
Doctoral Students	2
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	1
Docents (Adjunct Professors)	2

General description of the RU

The research unit ACM conducts basic research on applied mathematics and computational methods. Special emphasis is on numerical analysis problems modelled by partial differential equations (eigenvalue problems in particular), fundamentals in matrix theory and large scale computational methods in linear algebra. The unit is also responsible for teaching mathematics and developing undergraduate and graduate student mathematical curriculum primarily for engineering students but also for other departments needing applied mathematics. This includes teaching with Moodle and developing distance learning tools and courses internally and nationally. In short, the unit can be characterized as being a "department of mathematics" of an engineering university.

Current description of the RU (rating 4)

The research carried out by the members of ACM falls in general within the classical and well-established areas of applied mathematics and numerical methods with focus on the solution of PDEs and (generalized) eigenvalue problems. The research is in general of high quality and does provide advances in the field. However, the research cannot be considered to be truly groundbreaking as it mainly refines and improves standard approaches.

The team consist of 2 Professors and other scientific staff adding up to 9 members of the RU. The RU addresses two key research areas of the University of Oulu (OYO), namely, 'Digitalization and smart society' and (as a secondary topic) 'Sustainable material and systems'. The particular profile is described to be '6G-enabled wireless smart society' and 'Data insight for high-dimensional dynamics'. Clearly, the focal areas of OYO are well chosen and the profiles given by the RU are quite adequate and correspond to the expertise of the PIs.

In particular the mathematical analysis and the numerical simulation of partial differential equations (PDEs) as the main modeling tool for distributed processes in a spatio-temporal context provide the key for predictive models needed in the engineering community. The numerical simulation necessitates increasingly deep knowledge in numerical linear algebra. Given the size of the mathematical problems to deal with after proper discretization, sparsity related techniques and model reduction techniques have to be employed. Moreover, in the view of data-driven modeling and simulation very large-scale linear problems have to finally solved. Again, the proper interaction between continuous methods and numerical schemes is critical. Professors Ruotsalainen and Huhtanen have precisely their expertise in PDE-related problems and numerical linear algebra, respectively. In their work they address the right questions and provide solutions which have attracted a lot of interest within the communities of applied mathematics

and engineering. The secret behind the success of applied mathematics in particular in recent years lies in the fact that the research within mathematics is triggered and catalyzed by demanding applications.

The research carried out by the members of ACM falls in general within the classical and well-established areas of applied mathematics and numerical methods with focus on the solution of PDEs and (generalized) eigenvalue problems. The research is in general of high quality and does provide advances in the field. However, the research cannot be considered to be truly groundbreaking as it mainly refines and improves standard approaches.

Future potential of the RU (rating 3)

The scientific action plan reflects the current stressed situation for the research unit with fewer members than needed to perform teaching as well as research duties at a high level and absence of external funding. Thus, the major part of the scientific action plan describes this, admittedly somewhat grim, situation. However, what is badly needed is the realistic, coherent, and ambitious plan to reverse the situation with respect to personal and funding. The absence of such a plan is very unfortunate, as the field of applied mathematics is currently developing rapidly and much research is carried out on the developments of new ideas, methods and algorithms, and how to implement these on the current and future computer architectures – which now are accessible in Finland with the LUMI machine.

The strategic visions in the plan does not contain a plan on how the research unit can become a research unit at the highest international plan in a field, that is very important across a huge number of scientific disciplines and will assist in the solution of many societal problems.

The evaluation does not provide a careful discussion of the alignment of the research with the overall strategy of OU and the UN sustainable goals.

On the other side, the RU is on its way and heads into the right direction in order to cope as much as possible under given conditions with goals formulated. As said above, the panel members see the linkage between PDE-analysis and scientific computing on the base of modern numerical linear algebra as the key to further success stories. The international cooperation should get more funding in order to enhance invitation of international experts to work in the nice atmosphere of the university.

Highlights, strengths and development areas, recommendations and overall rating (3)

Highlights:

Application and data driven large scale numerical methods for spatio-temporal PDEs

Strengths and development areas:

The strength is in the Interaction of PDE-analysis and numerical linear algebra with engineering and computer science. Involving machine learning techniques and interlinking with mathematical optimization is a development area that has the potential to turn the RU into a cross section area for the engineering faculty.

Recommendations:

Extend the group by an expert in mathematical optimization, apply for collaborative grants jointly with engineers, seek collaboration with the applied mathematics in RU MathSci.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Biomimetics and Intelligent Systems (BISG), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 02

Primary panel: Natural Sciences and Engineering
Secondary panel: Biosciences, Health and the Environment

RU Leader: Röning, Juha

Professors: Röning, Juha

Other PIs: Frantti, Tapio – Celentano, Ulrico – Siirtola, Pekka – Tamminen, Satu – Suutala, Jaakko

Academic Staff in 2019	30
Professors	1
Senior Researchers	1
Postdoctoral Researchers	11
Doctoral Students	17
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	3

General description of the RU

Biomimetics and Intelligent Systems (BISG) conducts internationally acknowledged multidisciplinary research in the areas of Secure Programming, Robotics, Data Analysis, and Bio-IT. The first three groups are led by Professor Juha Röning and the latter by Professor Seppo Vainio. Our research personnel have core background in engineering and mathematics, complemented by knowledge in medical and humanities fields. This enables the main strength of the research unit as the capability to build bio-inspired, truly intelligent and secure systems with a holistic view on all the involved aspects. These dynamic systems are capable of active learning, understanding of and physical interaction with their complex and a priori unknown environment in real-time. Human is assumed as a part of this environment, both as a source and a target of the information. The application areas of our research include cybersecurity and data privacy, environmental monitoring with mobile robots, optimization of industrial manufacturing processes, industry 4.0, health and wellbeing systems, dependable Internet of things (IoT), and seamless artificial-natural systems.

Current description of the RU (rating 4)

The RU consists of two groups of very different standing and culture, which makes it almost impossible to give overall grades. The group of Prof. Röning is rather based on applications with few citable publications and strong projects, whereas the group of Prof. Vainio has some strong publications with unclear project portfolio.

The RU's research is strongly based on AI-applications in robotics and bio-engineering. The scientific focus in AI is on code security and robustness. AI is seen from the concept of explainable AI which is partly model-based. In this respect there is some originality both in the methodology and in technology. Nevertheless, there are many competitors world-wide that have a very simlar profile.

The researcher subunits are very actively involved in international cooperations, on the level of universities as well as with quite an impressive number of industrial partners.

There is no visible cooperation between the two groups of the RU and very little within the university of Oulu which is, in a sense, strange, as there are many RUs dealing with AI/ML techniques.

Future potential of the RU (rating 3)

It is very hard to judge the future potential given the structure of the RU: Prof. Röning is close to retirement, and the informations given by the group of Vainio are very, very general (Sustainability goals of UN). The new projects are challenging and aligned with the university's focal topics.

It is not apparent from the self-report and also from the interview in which way the proposed research is unique. Other than that, the expertise seems to be more on the configuration of high-level methods in the context of particular applications. The scale bridging from molecular medicine to AI-supported devices in wearables did not beome very clear. The potential for scientific publications in the application areas has to be validated in the future.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The RU will contribute to the PANDEMICS strategic research programme of the Academy of Finland. The goal is to get new insight into the impact of the pandemic on individuals and society using Artificial Intelligence (AI).

Strengths and development areas:

The groups lead by Prof. Röning are very strong in EU funded projects. Prof. Vainio's group has a good publication record. Interaction between these groups is rather weak.

Recommendations:

The future prospects of the group should be discussed on a University level. Maybe the RU should be reorganized and the groups should join other RUs also working on applications of AI.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Circuits and Systems (CAS), Faculty of Information Technology and Electrical Engineering
RAE2020 code: NSE 03

RU Leader:
Rahkonen, Timo

Professors:
Kostamovaara, Juha – Rahkonen, Timo

Other PIs:
Aikio, Janne – Jansson, Jussi-Pekka
– Nissinen, Jan – Nissinen, Ilkka –
Häkkinen, Juha – Vaynshteyn, Sergey

Academic Staff in 2019	28
Professors	2
Senior Researchers	5
Postdoctoral Researchers	10
Doctoral Students	9
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	8
Docents (Adjunct Professors)	7

General description of the RU

The research of CAS group is focused on circuits and system design using based on modern microelectronic technologies. The group leaders and sub-groups have partly overlapping research expertise, however, in such a way that each of the sub groups also has a specific research field. The group of prof. Rahkonen focuses on linearization of electronics with the emphasis on analysis and correction of non-linear distortion. His group has made fundamental work in explaining distortion memory effects in RF power amplifiers, but he was also involved with the development of time to digital converters, and the cooperation with group of Kostamovaara has led to numerous common and highly cited publications. Prof. Kostamovaara´s group focuses on pulsed time flight techniques and the development of related circuits, devices and applications. Addition to the above, assoc. prof. Nissinen has started his own subgroups since early 2019. As an example, CAS group has recently been very active in developing single photon detection based 2 D and 3 laser range imaging technologies. The specialty of this group is that in addition to electronics, it has strong experience also in optoelectronic circuits and devices.

Current description of the RU (rating 5)

The RU has a very long track record of high-quality work in the field of integrated circuit design, mainly regarding pulsed time-of-flight techniques, distortion in amplifiers, and more recently single-photon detection. As a whole, the RU shows excellent research with original contributions and high impact internationally. The research activities are solid and exhibit a good research foundation both in theoretical and experimental research topics.

The activities of the Rehkonen group contained both fundamental theoretical and experimental research work with very solid foundation, which exerts a strong impact on the 5G and 6G field of applications. The international competition in this fierce and the group has published too cautiously for a sustained international leading position in this research field.

The subgroup of Kostamovaara has an excellent track record and is world leading expert in mixed-signal circuit research, optoelectronic components and Lidar components. The group generated a strong impact on scientific developments internationally and contributed with numerous publications.

The RU has numerous national projects, partially with Academy of Science of Finland and partially with Tekes. The national impact is high, as exemplified by being part of a center of excellence, and by having several times an Academy of Finland professor. The research outcomes from the RU are clearly visible and followed internationally as well as on national level. The RU has lower than average number of international projects. The RU has to find a good mix of all funding schemes to remain competitive in the future and somewhat release from overwhelming teaching duties.

Future potential of the RU (rating 4)

Circuit and system design is of the highest relevance technologically and of societal importance for Finland. The RU seems to fit well the Oulu strategy. A variety of very interesting research topics are listed as a mixture of further research in areas with long heritage and some new topics entering the scene as time progresses. The scientific objectives are ambitious and reflect the demands of industry and society. There has been already an expansion of research lines with the installation of an additional associate professorship.

The goals set by the RU are realistic and can be fully reached with a very reasonable extrapolation of recent activities, even accounting for the generational hand-over in course. It would be helpful if the RU receives some operational support due to renewal of key personnel and the potential associated decline in externally funded research projects. The new topics of research are well chosen and promise good inflow of funding once established. It is less clear whether the current support by the university is sufficient to maintain this important RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU is world-leading in mixed-signal circuit research, optoelectronic components and Lidat components.

Strengths and development areas:

The RU has a very long track record of high quality work in the field of integrated circuit design. It is involved in numerous high-profile national projects. Its research is of immediate societal impact, and it impresses by many local collaborations.

The replacement of the activities of Prof. Kostamovaara presents a major challenge for the RU, but first steps have been taken. The number of international projects might call for an increase to maintain a healthy mix of funding schemes for a sustainable future. There is an overload by teaching.

Recommendations:

It would be helpful to support the ongoing renewal of key personnel by additional operational support. Recruitment of young people being difficult in the field, the RU might enhance mobility by participating in EU graduate schools. The RU is encouraged to increase its number of intensive international collaborations. It should be attempted to reduce the very high teaching load of this particular RU.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Center for Machine Vision and Signal Analysis (CMVS), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 04

Primary panel: Natural Sciences and Engineering

RU Leader:
Silvén, Olli

Professors:
Heikkilä, Janne – Kohno, Ryuji – Seppänen, Tapio – Silvén, Olli – Zhao, Guoying

Other PIs:
Zafeiriou, Stefanos – Liu, Li

Academic Staff in 2019	56
Professors	5
Senior Researchers	7
Postdoctoral Researchers	11
Doctoral Students	32
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	7
Docents (Adjunct Professors)	9

General description of the RU

CMVS is a creative, open and internationally attractive research unit that focuses on creating multimodal emotional interfaces for human-centered computing, energy and label efficient visual representation learning, recognition and reconstruction of complex 3D visual scenes, energy efficient embedded vision solutions, biomedical signal and image analysis and biometrics. The research unit is renowned for its expertise in computer vision, and it possesses a wide international collaboration network.

Current description of the RU (rating 5)

The RU has a highly interesting, innovative and original research program. The RU had a very strong and focused theoretical and experimental research record and impact in the scientific community, which somehow slowed down recently, due to reorganization. It has a solid foundation in this field and has contributed substantially in the past at the forefront of several topical areas. Overall the RU is well positioned in the scientific community.

The RU's publication output is of excellent quality and reflects the productivity of the RU teams. Most of the recent publications have been published in top international journals.

The senior members of the RU have an excellent record in their fields. Prof. Zhao has acquired a huge amount of project funding and an Academy of Finland Professorship. Several members of the RU have received a number of prizes and honors for their research, mostly in the area of computer vision. The RU is cooperating intensively with national and international research groups and industrial entities, which is considered a strong asset in the future development of the group.

Future potential of the RU (rating 5)

The RU has a clear and very ambitious scientific goals with high likeliness to produce signifcant results. The societal impact is very well recognized and the RU serves the society with many spin-offs, open provision of code and databases.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

- Academy of Finland professorship for Professor Zhao

- Severel high rank prizes for RU members

- Very good international standing in the field of pattern recognition

Strengths and development areas:

- Very good publication output

- Strong interaction between different groups of the RU

Recommendations:

Support with native speakers in teaching at undergraduate level is needed, as most of the senior members of the RU are not Finnish.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Chemical Process Engineering (CPE), Faculty of Technology
RAE2020 code: NSE 05

RU Leader:
Tanskanen, Juha

Professors:
Tanskanen, Juha

Other PIs:
Leiviskä, Tiina

Academic Staff in 2019	15
Professors	1
Senior Researchers	3
Postdoctoral Researchers	2
Doctoral Students	7
Researchers on Personal Grant	2
In Teaching only	0
Of these:	
Principal Investigators	2
Docents (Adjunct Professors)	3

General description of the RU

The Faculty of Technology at the University of Oulu is one of the leading experts in sustainable utilization of natural resources. Research on biochemicals, biomaterials, and generally on biorefining technologies is among the strengths of the Faculty. Chemical Process Engineering research unit (CPE) of the Faculty of technology merges the disciplines of chemical process engineering and bioprocess engineering and is strongly focusing in its research on sustainable utilization of Nordic raw materials such as forestry materials. Biomass engineering, and especially the existing technological gap in the sustainable utilization of lignocellulosics to biochemicals and -materials, is the inspiring source of the CPE research. The specific research areas of CPE are the chemical and biochemical conversion of biomass, novel products and processes in industrial water treatment and, recovery/separation process synthesis and evaluation. The combination of the research areas yields us the tools to bridge the technological gaps in the utilization of lignocellulosics to biobased products.

Current description of the RU (rating 4)

The descriptions in the self-evaluation report are very clear and honest. The different items are described according to the present situation, the risks are mentioned and some propositions are reported. The interview was very clear.

The research in the Chemical Process Engineering RU belongs to three main fields dealing with chemical and biochemical conversion of lignocellulosic biomass; process modelling and industrial water treatment (with bio-based materials). The research developed at the RU focuses on Nordic raw materials such as forestry materials and is in line with research focus area of the University of Oulu.

The RU is small with 2 PI's (1 professor, 3 Senior Researchers), 2 post-doc and 7 PhD students. It is likely that unsuccess for application to different fundings is due of this small size. All the people are involved in teaching activities. Even if the topics of research are quite different, there are some internal collaborations within the two subparts.

Main RU collaborations are with Finnish Universities (Åbo, Aalto) and Research institute (VTT) as well as with Northern Countries (Norway). Half of the publications are in collaboration. The RU has also recent collaboration with China (Shandong University) with common publications, research visit and PhD student hiring recently. Some other minor interactions with European research groups are built (visiting research in Poland). It is clear that the RU recently tried to improve international collaborations. 28% of the publications are involving international collaborations. The publications are well cited ones. More than 90% of the publications are lead by the RU. Thanks to the quality, the research has international visibility but due to small size of the group this visibility is moderate. Over the period 2013-2017, a significant increase for MNCS and MNJS was observed for the last year but this evolution needs to be confirmed.

The RU contributes to industrial challenges and claimed 6 patents. 15% of publications are with industrial partners. Close interaction with private companies allows to prepare PhD students to work in private sector after graduation.

The research funding level is good considering the size of the RU. Unfortunately, there is no international fundings up to now (main financial supports seem to be Academy of Finland and TEKES). The RU is well equipped by itself but it is costly to maintain the quality of equipment.

The RU was formed in 2014 after association of three research groups. Vacant position (Bioprocess engineering professor) was not opened and it seems that the size of the RU today is critical.

Future potential of the RU (rating 3)

The future objectives are focussed on three topics, the common axis being the sustainable use of lignocellulosic materials.

The use of biobased materials for industrial water treatment is original. Chemical modification of biobased (tannins) coagulants and their evaluation is one aspect of the project. Further water treatment will be developed (sulphate removal, chemical oxidation methods..) as well as the recovery of valuable components such as vanadium (from mining waste in collaboration with Norway).

As a second topic, biomass transformation via biochemical and chemical reaction routes will be studied. This includes the use of hydrolyzed lignin through a national project (PUMA) or the use of hemicellulose in combination with cellulose in biorefinery (ERDF). The objective to become national leader would need more manpower.

The last topic concerns the development of predictive modelling tools with the objective to applying the existing computational tools of natural sciences in order to have deeper molecular level description. Some commercial tools are now available. This topic will need stronger collaborations with complementary experts (natural science and quantum chemistry) which are not present in the group today.

These research axes are clearly associated to societal impacts and are of strong interest. Recruitment is essential to allow positive future to the RU.

Highlights, strengths and development areas, recommendations and overall rating (3)

Highlights:

The RU is well recognized in its research field.

The RU has increased its international visibility with some collaborations .

The RU has 6 patents.

Strengths and development areas:

The research topics are in line with research focus area of U Oulu.

The PI's are very dynamic despite they are only 2.

The interaction with private companies is good.

Recommendations:

The small size of the RU presents risk for the future. External recruitment or reorganization with other RU would help to consolidate the research topics of the RU.

High research funding is needed to maintain equipments to good level.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

CWC – Networks and Systems (CWC-NS), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 06

RU Leader:
Iinatti, Jari

Professors:
Iinatti, Jari – Katz, Marcos – Pouttu, Ari – Taleb, Tarik

Other PIs:
Hänninen, Tuomo – Haapola, Jussi-Pekka – Hämäläinen, Matti – Posti, Harri – Saarnisaari, Harri – Ylianttila, Mika

Academic Staff in 2019	56
Professors	4
Senior Researchers	6
Postdoctoral Researchers	12
Doctoral Students	31
Researchers on Personal Grant	0
In Teaching only	3
Of these:	
Principal Investigators	10
Docents (Adjunct Professors)	8

General description of the RU

Centre for Wireless Communications (CWC) at Faculty of Information Technology and Electrical Engineering (ITEE) was established in 1995 and provides high quality bachelor, master and doctoral level education in wireless communications and RF engineering. CWC – Networks and Systems (CWC - NS) Research Unit (RU) employs a personnel of roughly 70. CWC-NS operates in the heart of the strategic focus area of digitalization and smart society and contributes partly to all others, in particular to lifelong health. CWC-NS is heavily involved in the university profiling area 6G solutions for data driven society and the first and largest national science Flagship program on Sixth Generation (6G) wireless technology, 6G Flagship.

Future society in 2030 is data-driven and enabled by near-instant, unlimited wireless connectivity. The role of 5G/6G for us is to cognitively connect every feasible device, process, and human to a global information grid. We are therefore only now at the brink of an information revolution, and new digitalization markets will offer significant revenue expansion possibilities for those who react fastest to new opportunities. 5G and beyond-5G (B5G) network technology offers numerous opportunities for various verticals, and new value chains and business models are introducing a paradigm shift to the old communications service provider market in transforming toward digital services. However, important efforts are still required prior to making 5G a success and growth story for the industries developed around the 5G-beneficial vertical sectors. Considering the different development cycles of each vertical too, a full trolley of the potential advances and vertical transformations will also continue to be deployed in the 6G era. Given the expansion potential of factories (including worksites), they are a natural choice for a vertical to be researched. Furthermore, logistics and transport (ground air, sea), energy, and health are among the biggest beneficiaries of the productivity increase with digitalization. Smart Cities and its' digital services are obviously an opportunity rich environment to do wireless research. Further to the business verticals listed above, public safety (critical communications) has been singled out. Based on these, the fundamental research at CWC-NS is divided into wireless networking and wireless systems.

Current description of the RU (rating 5)

The research of the RU is of excellent quality in terms of originality, significance. The overall goal for CWC-NS is aligned with the 6G Flagship one. Their strong focus is on developing 6G Test network from existing 5G test network, being an efficient tool to steer the research towards common goals in different verticals. In fact, the impact of the RU's publications has been boosted since 2018-19 (google scholar consultation by the reviewer), when this flagship initiative begun.

The RU studies hybrid commercial-dedicated solutions, mainly for short range communications. The most visible applications are wireless medical communications for personalized healthcare, and wireless body area networks. Network security has an important weight in CWC-NS research.

Overall, this research focus is excellent in its originality. The research methods are theoretical and mathematical analysis and synthesis, Monte Carlo computer simulations, as well as true implementation and measurements in their 5GTN platform for large scale trials, which is very good. The theoretical and empirical contributions are very diverse and combine knowledge of communication networks and link-phy layer. For instance, one of their reported three most downloaded thesis is about detection algorithms and FPGA implementations for SC-FDMA uplink receivers. This RU has also carried out studies on channel propagation characterization.

Future potential of the RU (rating 4)

The future strategy consists of five independent strategies, one for each research group. These strategies focus on group specific themes and their extrapolation into the future. Though the concluding paragraphs of each group specific strategy aims at pointing to connections to the research of the other groups, these connections do not become visible in the main parts of the group specific strategy. Each of the research group specific strategies clearly address cutting edge challenges.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Development of the 6G Network Technology.

Application of the 6GNT in the medical domain.

Strengths and development areas:

Strengths:

- Research addressing the full stack of 6GNT.
- Core participation of the Oulu University and national development of the 6GNT.

Development area:

- Collaboration between the different groups of the RU is lacking
- Developing a profile as a RU.

Recommendations:

The research could be complemented with a stronger network component, to better differentiate CWC-NS from CWC-RT.

The complementary research of the different groups could be better related in order to develop synergy effects that are so far only visible as potentials.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

CWC – Radio Technologies (CWC-RT), Faculty of Information Technology and Electrical Engineering
RAE2020 code: NSE 07

RU Leader:
Juntti, Markku

Professors:
Latva-aho, Matti – Juntti, Markku – Pärssinen, Aarno – Rajatheva, Nandana

Other PIs:
Alves, Hirley – Bennis, Mehdi – Berg, Markus – Codreanu, Marian – Matinmikko-Blue, Marja – Tölli, Antti-Heikki

Academic Staff in 2019	90
Professors	4
Senior Researchers	10
Postdoctoral Researchers	18
Doctoral Students	58
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	10
Docents (Adjunct Professors)	13

General description of the RU

Centre for Wireless Communications (CWC) at Faculty of Information Technology and Electrical Engineering (ITEE) was established in 1995 and provides high-quality bachelor, master and doctoral level education in wireless communications and RF engineering. CWC – Radio Technologies (RT) Research unit employs personnel of almost one hundred. The unit operates in the heart of the strategic focus area of digitalization and smart society and contributes significantly to all others, in particular, to sustainable materials and systems. CWC-RT leads the university profiling area 6G solutions for data driven society and runs the first and largest national science Flagship program on Sixth Generation (6G) wireless technology. The fundamental research at CWC-RT focuses on radio access network (RAN) technologies, signal processing, radio frequency (RF) engineering, antennas and propagation, machine learning (ML) and artificial intelligence (AI) for and over networks. The developed technologies are applied, e.g., in beyond

5G and 6G system design, wireless vertical applications and services. The main research objective of the unit is to create the future wireless 6G systems and technologies needed to enable power, energy and spectrally efficient and sustainable connectivity for the future smart society and its ecosystems. The research methods are theoretical and mathematical analysis and synthesis, Monte Carlo computer simulations, as well as true RF system, antenna and integrated circuit (IC) design and measurements. The main research approach is model based, but also true measurement data is applied in data driven ML research. The theoretical framework is based on communications and information theory, electromagnetism and applied mathematics. Experiments and designs are implemented using RF

laboratory and measurement equipment. 5G Test Network (5GTN) is used as the core implementation and demonstration platform for larger scale trials. The expected results and impact will enable data driven society via realization of enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable low latency communications (URLLC) services using the 6G network architecture, which will be orders of magnitude more energy efficient and reliable than the current networks. As concrete research outputs, the unit produces new wireless system design and optimization methods, transceiver algorithms and architectures, and RF circuit and antenna designs. As tangible deliverables, the research outputs include scientific publications, invention reports and patents, technology demonstrations, hardware circuits, software and algorithms, and most importantly master and doctoral graduates.

Current description of the RU (rating 6)

The RU is a large research unit (about 100-strong) that has developed a number world-leading research outputs with a strategic focus to the area of digitalization and smart society and contributes also to sustainable materials and systems research. CWC leads the university profiling area 6G solutions for data

driven society and runs the first and largest national science Flagship program on Sixth Generation (6G) wireless technology.

The methodological approaches are very solid, and cover a wide range with fundamental research on radio access network (RAN) technologies, signal processing, radio frequency (RF) engineering, antennas and propagation, machine learning (ML) and artificial intelligence (AI) for and over networks. These are highly creative and original research directions and initiatives with the main research objectives to create future wireless 6G systems and technologies needed to enable power, energy and spectrally efficient and sustainable connectivity for the future smart society and its ecosystems.

There is a healthy mixed and very solid methodological approach of theoretical and mathematical analysis and synthesis, Monte Carlo computer simulations, as well as true RF system, antenna and integrated circuit (IC) design and measurements.

This RU has certainly carried out a very creative and original research. CWC-RT has a central role in pioneering 6G research through 6G Flagship. It organized the first two 6G Wireless Summits. As an output, the world's first 6G white paper was published as a joint vision on the views that 70 experts shared in 2019. Many of the papers have gained significant numbers of citations. In Section 1.3.A, the key results having the most impact measured via the numbers of citations are clearly identified. Overall, the RU's research originality and impact are solid and outstanding.

Future potential of the RU (rating 6)

The RU builds upon previous successful research and plans to benefit from the University's "the strategic focus area of digitalization, smart society and sustainable materials and systems." This latter is a particularly important direction, given the strategic R&D at international level. The RU has integrated the Institution's strategy into their mid- and long-term research planning. Based on past performance and the evidence provided, it is very likely that the RU will remain at the frontiers of internationally cutting-edge research and research training. For this, they may need to spread out a bit their portfolio in terms of age-profile (see the imbalance of senior academics vs PDRAs, PGRs), and secure assurance from the Institution to recruit suitable succession. This should be done "now". The RU has recognized that their research has exceptionally important societal impact (6G). They build on this and have provided sufficient credible evidence that there is clearly defined strong vision of how to expand and strengthen further this impact, even with policy makers at highest international standards (e.g. Finland, USA). The UN sustainable development goals are considered clearly by the RU and their research strategy is aligned with UN sustainability goals (see the seven examples of SDGs).

The solid trajectory of CWC-RT, together with its high involvement with the 6G Flagship initiative, gives confidence on the RU's goals feasibility.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The RU has outstanding international recognition and has a well-established interaction with other research groups.

The RU gathers personnel with large range of expertise which allows to address issues on many societal topics

The RU is leading the 6G flagship initiative, which is having impact worldwide.

Strengths and development areas:

Recommendations:

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Environmental and Chemical Engineering (ECE), Faculty of Technology
RAE2020 code: NSE 08

RU Leader:
Muurinen, Esa Ilmari

Professors:
Keiski, Riitta – Laitinen, Risto – Ruusunen, Mika
– Gehör, Seppo

Other PIs:
Bezuidenhout, Daniela – Huuhtanen, Mika –
Muurinen, Esa Ilmari – Ojala, Satu

Academic Staff in 2019	44
Professors	4
Senior Researchers	7
Postdoctoral Researchers	9
Doctoral Students	20
Researchers on Personal Grant	4
In Teaching only	0
Of these:	
Principal Investigators	7
Docents (Adjunct Professors)	9

General description of the RU

The growing demand for the development of new sustainable production processes and the need to make the existing processes more environmentally benign are the main motivations for the Environmental and Chemical Engineering Research Unit (ECE). The unit has gained valuable expertise and scientific understanding in the fields of material development, characterization, unit operation development, process modelling and control, advanced data analysis and optimization, and sustainability assessment. The research work in ECE is strongly connected to applications aimed at the benefit of society in promoting new products and materials as well as improving the environment and economy. ECE collaborates with national and international academic and industrial partners and disseminates the results across these networks.

Current description of the RU (rating 5)

The research performed in the RU Environmental and Chemical Engineering is based on the expertise of their recognized members. It concerns the development of more environmentally benign process and covers from fundamental aspects to more applied developments. More specifically, the RU develops the preparation and characterization of materials for range of applications in catalysis or absorption field and they have shown significant inputs in the development of some characterisation technics including in situ /operando approaches. The RU has developed some CFD models including advanced data analysis.

They are internationally recognized and the RU is collaborating with several research groups either within University of Oulu, Finnish laboratoratories and also international ones. The success of these collaboration is underlined with the percentage of publications in collaboration (83%) or with international collaborations (53%). They are also involved in European programs which ensure visit (IN and OUT) of researchers or students and which is a strong signal of international visibility. More specifically, some well-recognized researchers are members of RU. They allowed to gain international visibility. Recent recruitment of an associate professor from abroad is also a proof of international stature.

The scientific coverage of RU concerns physical, chemical, environmental engineering and inorganic chemistry and is representative of the fields of research and the coexistance of experts in these different topics allowed to cover a large range of domains from fundamental science to industrial applications through applied science which is claimed to be unique in Finland.

The field of research are in line with societal issues and the research topics of ECE are by nature, important to address growing demand for the development of sustainable research. The collaboration with industrial partners is also important both with direct interaction or within national programs. Surprisingly no patent was mentioned during the period.

The global research fundings of ECE are good. It is noteworthing that fundings come from several sources (Academy of Finland, EU programms, private companies) avoiding depending on one specific funding source. Efforts to apply to more competitive fundings are planned by conducting joint projects with

members from different research areas. The main goal is to increase the amount of international (EU) fundings. The RU is well equipped or has access to desired large equipment essential to carry out the projects.

ECE is a combination of 3 former research groups and the final organization took place in 2019 so internal managment within RU is still under progress. Furthermore, retirement of some personnel with recruitement of new ones drives to some changes in the main expertises which must be taken carefully into account.

Future potential of the RU (rating 5)

Following recent reorganization of RU, the objectives are focused on some topics where joint efforts of the different members should operate from fundamental to applied domains considering Sustainable Development Goals of UN.

The development and characterization of materials for specific applications is the basis of one research topic. Thanks to large interactions with other RU, materials with specific properties will be designed and characterized. Judiciously, the possibility to combine "classical" analysis with intelligent data analysis method is proposed. Tools are available to scale up the studies to fullfill requirements of industrial partners. CFD will be combined with particle flow simulations and kinetic modelling.

Further works will focus on the development of research into real environments (automatic measurements, control and optimization) including utilization of AI methods. The high challenging objective is to design within 6 year an efficient hybrid technology combining control and AI technologies.

Within next 6 years, 20 PhD students should be graduated, and 150 publications are expected (similar to present report) with the objective to increase the quality of research outputs and the societal impact.

Additional objective is to increase the collaboration between the members issued from different teams (as well as new staff) which should increase performances of the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU has international recognition and has a well-established interaction with other research groups.

The RU gathers personnel with large range of expertise which allows to address issues on many societal topics.

Strengths and development areas:

Well known experts in the RU with a good level in publication (quality and quantity).

The RU is well equipped and has access to larger equipment when needed.

The financial support is good.

The RU covers research projects from fundamental up to applied sides.

Recommendations:

Many changes occurred in the RU with recent reorganization, retirement of some persons and new expected recruitment needs careful attention to maintain consistency of the RU.

Care must be taken to maintain high quality equipment.

The involvement of a newly recruited young PI (Daniela Ina Bezuidenhout) should be better highlighted in the global research program of the RU in order to clearly show interaction with the other partners of the RU.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Fibre and Particle Engineering (FPE), Faculty of Technology
RAE2020 code: NSE 09

RU Leader:
Illikainen, Mirja

Professors:
Illikainen, Mirja – Oksman, Kristiina

Other PIs:
Liimatainen, Henrikki – Kinnunen, Päivö

Academic Staff in 2019	58
Professors	2
Senior Researchers	4
Postdoctoral Researchers	28
Doctoral Students	22
Researchers on Personal Grant	1
In Teaching only	1
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	5

General description of the RU

The Fibre and Particle Engineering research unit (RU) promotes the circular- and bio-economy through material research. We are an interdisciplinary research unit developing novel materials and processes based on industrial inorganic side streams and lignocellulose (wood, and industrial and agriculture side streams). Our scientific core competences are related to sustainable inorganic binders, i.e. cement-like materials, and cellulose nanomaterials and their advanced applications. We also contribute to university education in degree programs of particle engineering, circular economy, and bioproduct technology. We collaborate closely and globally with industry, research institutes, and other universities.

Current description of the RU (rating 5)

The main contribution of the RU to the research on inorganic binders is related to high volume applications of inorganic side streams and alkali-activated materials. The lignocellulose group has clearly initiated the use of deep eutectic solvent systems as novel pretreatments for cellulose nanofibril production.

The international collaboration level has continuously increased over the last few years. This is evidenced by the growth in the number of publications co-authored with international partners, the number of joint projects and the co-supervision of PhD students and postdoctoral researchers. It is a clear indication of increased international visibility.

There have been significant changes in the research focus areas and major organizational modifications in the RU during the last five years. These facts have a strong impact on the scientific production of the RU. The RU's publication output is significant as expected from the high numer of postdoctoral researchers and PhD students. Quality is also good, but care must be taken to limit the number of publications in MDPI journals, which strongly increased in 2019.

Sustainability is a highly relevant topic and perfectly in line with research focus areas of the University of Oulu. The societal impact of the RU can therefore be considered as high. The collaboration with industrial partners is also an important asset of the RU, demonstrated through numerous industrial projects, an important network of companies and the creation of spin-off companies. The RU has a strong presence in civil society and in the media.

There are currently 22 PhD students and 14 postdoctoral researchers in the RU, which is quite high considering the number of senior researchers. PhD students are recruited on the basis of an international call. They have at least 2 supervisors. The balance between research and PhD supervision is good since PhD funding generally originates from research projects. Researchers from the RU are also supervising around 5 MSc thesis per year. The RU is involved in teaching at the bachelor, master, and postgraduate levels in courses closely related to its research areas. It is planned to organize national/international collaborations to strengthen the links between research and teaching.

The RU is well equiped with newly renovated facilities. Services and facilities available at the RU are available for consultation via its webpage and the contact person is provided. Three laboratory technicians are part of the RU to support research. Access to the facilities of the University of Oulu and the collaborative network is available. The RU has experience with synchrotron facilities at MAX IV and CLS. The infrastructure is conducive to support high quality research. It seems that open discussions are encouraged in the RU. Social activities are organized. The results in the University Wellbeing questionnaire in 2017 and 2019 are very good. The principles of research ethics and collegiality are emphasized at the RU level, but also university level.

The members of the RU are highly qualified in seeking research funding. They are well recognized in their respective research fields by their peers. The developed strategies have been followed by different research groups.

Future potential of the RU (rating 5)

High potential research avenues are identified, which fit with the expertise of the RU. The RU is engaged in research areas based on circular- and bio-economy, which address high societal needs and are expected to continue to attract significant funding calls. The recent rapid growth of the RU in terms of senior researchers offers significant opportunities. The RU considers UN Sustainable development goals and the conducted research is in line with faculty strategy. All indicators are green to reach the aspired level of research: a good financial situation, topical research areas, a massive and recent recruitment of senior staff. The viability of the RU is ensured.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU members are well recognized in their research field.

The RU has a strong presence in civil society and in the media.

Strengths and development areas:

The RU is engaged in a topical research area, perfectly in line with research focus areas of the University of Oulu.

The research funding situation of the RU is very good and it is well equipped.

The RU is actively engaged in collaborations and has a strong network of industrial partners.

The RU is well involved in teaching at different levels in courses closely related to its research areas.

The recent rapid growth of the RU in terms of senior researchers offers significant opportunities for expanding the impact of its research.

Recommendations:

The recruitment of researchers on an international basis with different scientific backgrounds should be strengthened.

Care must be taken to avoid taking the easy route and limit the number of publications in MDPI journals.

Care must be taken to keep equilibrium between the two teams of the RU, recruitment for the lignocellulosic research team would help.

Collaborations between the research teams of the RU must be engaged.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Industrial Engineering and Management (IEM), Faculty of Technology

RAE2020 code: NSE 10

Primary panel: Natural Sciences and Engineering
Secondary panel: Culture and Society

RU Leader:
Haapasalo, Harri

Professors:
Haapasalo, Harri – Kess, Pekka – Kujala, Jaakko – Tervonen, Pekka

Other PIs:
Aaltonen, Kirsi – Reiman, Arto

Academic Staff in 2019	26
Professors	4
Senior Researchers	4
Postdoctoral Researchers	3
Doctoral Students	15
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	7

General description of the RU

Industrial Engineering and Management (IEM) is a research unit within the Faculty of Technology. IEM conducts relevant research in its field, provides teaching, and influences the society. The IEM discipline combines engineering and technology, business economics methods, and the human factors and behavior. IEM is unique in its multidisciplinary approach and the integrative nature provides value and enhances efficiency and effectiveness in organizations. The IEM research focuses specifically on the following areas: product management, project business, well-being at work & productivity, and operations and supply chain management. Overall, IEM explores versatile phenomena within its focus areas and solves problems by combining the multidisciplinary perspectives. The research of IEM is applied by nature. The research is conducted in a close cooperation with different organizations, the industry being "our laboratory". The four IEM research focus areas serve a variety of industries. The research has significance for science and society, specifically via the multidisciplinary approach, and added value to a variety of fields and organizations.

Current description of the RU (rating 5)

The RU Industrial Engineering and Management (IEM) conducts multidisciplinary, applied research to provide expertise related to organizations, management and their problem-solving challenges. Their research is inter-disciplinarily oriented and closely linked to (in particular the local/regional) industry (claim: "industry is our laboratory"). The research is focussed on four key areas, all of which have international relevance (product management, project business, well-being at work & productivity and operations and supply chain management). The four focus disciplines or themes have emerged historically and appear from an outside perspective to be a rather random choice – there is no rationale provided why an IEM research unit should focus on these particular topics or this bundle of topics. In particular within the project management discipline, the RU's research is visible within the international research community. However, the other three areas are gaining increasing academic attention.

The RU applied a variety of methods, both qualitative and quantitative – this appears solid and suitable for the nature and the broad variety of themes adressed. The group is relatively small but the international standing of their contributions is evident from their increasing citations and also their increasing ability to publish in top-tier journals. Their involvement in the editorial boards of key journals in their area along with their involvement in key international collaborations and best paper awards is indicative of their standing in the field. The RU's solution-oriented approach provides relevant contributions to industry and organizations and is tailored perfectly to the field's needs and practical expectations. Theoretically, however, it is not clear how or whether the research is leading in the sense of being path breaking, pioneering and of directing to new tracks the theory that corresponds to the related field.

The RU shows a strong development towards higher-quality, peer-reviewed, and internationally recognized publication outlets. The attention to national or to Scandinavian journals for publishing work of strictly local or regional relevance is well justified and makes perfect sense. The RU's publication strategy is planned carefully with a view to gaining the most impact either internationally or nationally and to taking into account the level of the author (e.g. allowing doctoral students to gain publishing experience in lower level journals). The RU's publication strategy considers multiple factors when choosing publication outlets (journal ranking, learning potential, internationality vs. national necessities, impact, visibility). Training and support as well as engaging in international collaboration are all identified as mechanisms for supporting the desire to improve the RU's competitive position vis-à-vis publication. However, turnover of staff is noted as a barrier to achieving their publishing goals. The publication strategy varies for each of the four focus areas. Project management as well as product management are in a stronger international position than are "Well-being at Work and Productivity" and "Operations and Supply Chain Management". The RU is aware of this development potential.

Future potential of the RU (rating 5)

For 2020-2025, the RU aims to achieve on average per year: 6 doctoral degrees, 40 peer reviewed journal articles, 16 conference articles, 900 k€ external funding. This implies a constant number of PhD students at the current level (good fit, given the current balance of PhD students and supervisors), a similar quantity but higher quality of scientific publications (continuation of the current development) and a very high increase of research funding (appears to be ambitious).

The plan is in parts ambitious without being unattainable. It is evident that the unit is directed at developing even more the practical intent of its disciplines. It is not very clear how all these plans would be of world-leading research originality but it is certainly clear that they will have a heightened societal impact of the kind that both the university and the UN goals for sustainable development would favour and encourage. The RU aspires to continue its long tradition of positively impacting industry, entrepreneurship and society. The RU wishes to transform industry along lines of digitalization and sustainable development. It is also inclined to further research on both the subjective and objective aspects of well-being at work and outside working hours. Topicwise, each of the four disciplines within the RU outlines a rather broad portfolio of research themes. These themes fit well into their areas of expertise. However, the degree of novelty and uniqueness is not very high.

The RU does not utilize any research infrastructure (e.g. their own support staff for funding applications). The greatest threat to its success is likely to be to have to contribute even more to infrastructure that does not help it achieve its ambitions.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU is aware of the pivotal role that its research may play for society, in particular the development of the local/regional industry. The RU understands its contribution to society in creating research-based knowledge that serves as a foundation for the generation of wealth and prosperity (= enabler for businesses and public organizations to create sustainable value).

The overall small size of the RU apparently allows for a collaborative and supportive environment with many activities being considered a joint effort. Focus areas and corresponding leaders have congenial, informal contacts and exchanges that are supportive of research and uplifting of the research spirits of this small unit.

The RU has a good balance between research, doctoral supervision and teaching. Doctoral researchers are fully integrated into the unit and often engaged in project work – a typical approach within this field of research. The unit is attractive to doctoral students, both full-time and industry-based. Teaching is research-led and students often get the opportunity to contribute to research projects as part of their classes, giving them very good experience of research in practice and the problems that industry is facing.

Strengths and development areas:

The RU produces about 45 publications annually (including scientific books) – for a team of 11 experienced researchers and 15 PhD students, the productivity seems to be high. However, not all of the chosen publication outlets are of high quality and the transition of the emphasis from books to international peer-reviewed journals seems to be still ongoing.

It is noteworhty that the performance between the four disciplines united in this research units varies – with some disciplines (in particular, project and product management) achieving higher levels of productivity. Furthermore, the influence and visibility within Finland seems to be much higher than internationally.

External funding accounts for roughly 50% of the RU's operating budget (this proportion has been rising over time). Most of the funding, almost 90% (circa 481,000 EUR) is national funding. In addition, they attract circa 56,000 EUR of international funding. This funding is mainly in connection with business/industry and this ensures that the research is relevant. The RU states that it wants to broaden its funding base, including more international sources. The RU's funding applications are supported by the Faculty of Technology and will follow their processes. They do not have their own support staff to help them with this.

Recommendations:

1. Support staff: The RU is largely dependant on external funding, however, they do not seem to have their own support staff for this.

2. Focus on novelty: The RU focusses on applied research. While this is a suitable path (in partiuclar considering their role within the regional ecosystem), the team might want to consider using their intense network and data access for a balanced portfolio of applied and fundamental research.

3. Connecting themes within the RU: The existing teams within the RU have emerged over time and provide a heterogeneous picture in terms of themes, methods quantity and quality of research outputs. From an organizational design perspective, this is a weakness as it hinders synergies at the interfaces of the teams and does not provide any guidance for the overall team development. We would recommend a long term strategy of what the RU stands for and how each of the teams contributes to the joint objectives. This would further allow to reveal any potential blank spots and provide insights for future recruitment.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Intelligent Machines and Systems (IMS), Faculty of Technology

RAE2020 code: NSE 11

Primary panel: Natural Sciences and Engineering

RU Leader:
Liedes, Toni

Professors:
Ikonen, Enso

Other PIs:
Liedes, Toni

Academic Staff in 2019	12
Professors	1
Senior Researchers	3
Postdoctoral Researchers	1
Doctoral Students	6
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	2
Docents (Adjunct Professors)	2

General description of the RU

The main focus of the Intelligent Machines and Systems (IMS) research unit is to study the behavior of dynamic systems in a broad sense. IMS conducts research on:

- theory and methods of control and systems engineering, with applications in process and energy, machine diagnostics theory, methods and applications,

- modeling and simulation of industrial processes, machines and controlled systems.

IMS is composed of two research groups: 1) mechatronics and machine diagnostics, and 2) systems engineering. Both groups provide teaching for engineering students at the University of Oulu. The education provided by IMS covers control theory from basics to advanced methods, automation systems, modeling and simulation tools, sensor, actuator and computer technology as well as methods for machine diagnostics. IMS supervises theses in BSc, MSc and PhD levels. Education is developed collaboratively with other regional education institutes such as Oulu University of Applied Sciences (OAMK) and Educational Consortium OSAO.

Current description of the RU (rating 4)

Development of the RU is on the modelling, analysis and control of dynamic systems, clean technologies and design/production. The RU is competent, with an emphasis on applied research. Mechatronics and machine diagnostics is strong, including precision mechanics, medical robots and machinary diagnostics. Papers are identified based on quality and metrics, ranging from operational research, boiler control, diagnostics and application of AI. The two research groups work with analog and discrete production systems respectively. Both groups work tightly in collaboration with industry, which occasionaly results in delays in the publications. The research themes are substantially defined by the strong collaboration with industry.

The RU is involved in a large number of projects related to local industry. In addition to cooperation in the context of industry financed or externally funded applied research projects, the RU engages in the development of a company and competence clusters. For example, it runs an open innovation lab, and is part of a large project "High-tech ICT Leverage from Long-term Assetization" addressing commercialization of innovations by SMEs.

Future potential of the RU (rating 5)

There is a clear focus on aiming to improve performance, efficiency and sustainability of complete systems – this is feasible compared to tackling complete systems. The ability to take advantage of digitisation is highlighted. Overall the RU will continue to focus on industry needs. The merging of MEMD and SYS centres in 2019 is discussed and the potential and challenges for collaboration/ interaction between the areas for developing synergies are considered. On the whole, there are plans provided in the self-assessment, but they are quite broad. The strategy also seems to be rather conservative, emphasizing the continuation of the successful collaborations with industry, and highlights the connection to the challenge of making production more environmental friendly. A bigger picture of the future is beneficial.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The RU engages in the development of industry/companies and competence clusters.

The Innovation lab by the RU is forstering commercialisation of innovations for SMEs.

Strengths and development areas:

Strengths

- Strong cooperation and interactions with industry.
- Strong international research network.

Development Areas

- Leveraging existing international collaboration for joint high level publications.
- Potential to develop synergy between the research strengths of the two groups.

Recommendations:

The RU would benefit from explicating the common denominator and synergies of the research activities.

Existing collaboration has potential to result in high level internationally authored publications.

Strengthen internal collaborations.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Human Computer Interaction and Human-Centered Development (INTERACT), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 12

RU Leader:
Iivari, Netta

Professors:
Iivari, Netta

Other PIs:
Kinnula, Marianne – Lanamäki, Arto

Academic Staff in 2019	17
Professors	1
Senior Researchers	4
Postdoctoral Researchers	4
Doctoral Students	6
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	3
Docents (Adjunct Professors)	3

General description of the RU

INTERACT aims towards equal, democratic and sustainable society through research and education on human-centered design and digitalization, contributing to Human-Computer Interaction (HCI) and Information Systems (IS) research with 3 research themes: Politics of design (PD), Digital Transformation (DT) and Usability and User Experience (UUX). For PD, the unit is internationally recognized for high quality research on empowerment of children through design and Making, with extensive collaboration with schools and educational administration. The DT stream is a recent opening, contributing to IS research with understanding of digital technologies' role in industry and organization level transformation and the complex relationship between public policy/law and technology, in collaboration with the Finnish taxi industry, involving policy makers, governmental institutions and companies. UUX research builds on 30 years of INTERACT research with focus on defining and evaluating usability and UX of digital artefacts, theoretical development of usability and UX concepts and new methods development for socio-technical digitalization.

Current description of the RU (rating 4)

The INTERACT RU is clearly a group in transition: Partly, due to building up a research environment in a group defined by its teaching duties, partly, as the senior professor has handed over the baton recently. The research of the group focuses on relevant and creative themes based on research with external stakeholders. Human centered design, the common theme of the research, is addressed through a focus on co-design interaction design with children, digital transformation and political design combining the individual-level user experience with organizational and societal dimensions of digital transformation and design politics. The themes are connected to innovative and unusual application domains, like usage of IT for educational purposes and the research on digital transformation together with the taxi industry.

The RU scientific record is very good and bridges between Information Systems and Computer Human Interaction etc with limited impact on visionary research in the field. The research methodology is solid however with limited theoretical background and push.

Especially, the research on interaction design with children is visible internationally. Both in the Scandinavian IS community and the Interaction Design with children community, the Oulu group is well-known and well-reputed. The RU collaborates also with major Finish universities, as well as with universities in Europe and US.

The sound reputation also becomes visible in a surprising strong track record in European projects of the group.

Future potential of the RU (rating 5)

The self-evaluation presents a well-thought through and ambitious vision, which will result in an excellent position within the scientific community. Human centered design is addressed along 3 dimensions that are connected to the three research foci: individual – interaction design -, organizational – digital transformation -, and societal – political design. For each of the themes the strategic goals are projected into the future.

The objectives are very clearly described and measured against societal challenges. Clear measurable improvements in research output are defined. The RU has defined its goals along the University strategies as well as societal needs and expressed challenges.

The goals set by the RU are realistic and can be fully reached. The RU starts from a good research position and has identified goals, which will sustain or even improve this position.

The strategy could be more actionable, if concrete stepping-stones could be defined, like e.g. externally funded research projects related to the specific areas.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Clear understanding of how research themes and perspectives complement each other.

Strong publication record.

Strengths and development areas:

Strengths

- Dynamic and growing group.
- Clear strategy

Development areas

- Cooperation with industry and societal actors could be improved.
- International ties could be strengthened

Recommendations:

The RU has a clear and ambitious strategy, that outlines the path for future development. The next step would be to define actionable steps.

The RU might work on recruiting international researchers, maybe through Academy of Finland grants allowing for part time affiliation.

Oulu University needs to assure a healthy balance between internal funding for teaching and for research.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Kajaani University Consortium (KUC), Regional Unit
RAE2020 code: NSE 13

RU Leader:
Virtanen, Vesa

Professors:

Other PIs: Jaakkola, Mari – Kilpeläinen, Pekka – Virtanen, Vesa

Academic Staff in 2019	19
Professors	0
Senior Researchers	4
Postdoctoral Researchers	0
Doctoral Students	15
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	3
Docents (Adjunct Professors)	2

General description of the RU

KUC and its research unit MITY develop and apply measurement technologies in several fields on science and industry. They are a regional institutes serving by their expertise primarily region of Kainuu, but also whole Northern Finland. MITY is focused on two large main areas: cleantech and health & wellbeing. Its main developmental interests are real-time monitoring methods for environmental and waste waters, point-of- care biosensors for diagnostics and self-monitoring, and connected to bioanalytics of natural raw materials, processing and enrichment of plant-based material to high-value products. Despite of focusing on industrial collaboration and developing innovations of its own for commercialization, MITY publishes its work in leading or good international journals and has a wide international collaboration network. Besides MITY, KUC includes unit Adult and Continuing Education Services AIKOPA offering university level education and courses to companies and public organisations (mainly teachers at schools).

Current description of the RU (rating 5)

As the mission of present research unit is to disseminate and make use of advanced technological and scientific knowledge rather than producing new science, many of the above questions are not those that are required to quantify the success of the present research unit.

However, the RU does produce new science at a high level and is publishing this research in the relevant journals, including some publications in the very good journals. The research performed is in general multidisciplinary.

Based on the unit's traditional focus on measurement technology, the unit has branched out and is supporting a broad range of local industries and public partners. To exemplify the very broad range of expertises that the unit provides, it can be mentioned that the unit has supported industrial developments within extraction technology to make optimal industrial use of local products including lingonberries, supports the development of clean-mining techniques with improved instruments for measuring pollutants, as well as the development of saliva-based methods to detect insulin levels for early detection of diabetes.

The research unit does thus provide very competent assistance to a significant number of different private industries as well as public interests. It is thus very well aware of its important societal role and provides very important assistance to developments in the local private and public sector.

Future potential of the RU (rating 5)

Societal impact is core to this RU and is excellently accounted for. The RU presents highly interesting fields of activity for the next years that build on further developments of their measurement technology and will lead also to visible research output. Thus, the unit will continue its developments for clean tech

for sustainable mining, bioeconomy, health and wellbeing, as well as provide support for the local tourist industry. The continued work on biosensors and optimal use of the locally grown fruits or berries is very promising. The unit is unique in the very broad line of expertise it commands.

Given that a University as Oulu must play a very strong role in vitalizing local companies with first-class scientific expertise, the RU seems very well placed in its overall strategy.

The research of the unit is in line with many of the UN-goals for sustainability and will support their realization at the regional level.

The realization of the Scientific Action Plan is far from trivial, as it requires continued influx of expertise as well as continued funding many units, including European, National, OU, and private and public regional partners. However, taking the unit's accomplishments from the last period into account, the goals are highly realistic and feasible. The realization of the goals is subject to the constraint that the region continues to fund the RU. This is absolutely required for its continued existence and development.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Competent support to local industry and the public sector within a large number of different fields of expertise.

Strengths and development areas:

The major strength of the research unit is its broad range of competences and its willingness to engage in new and difficult development projects. The unit is therefore a significant contributor to the development of the local industry in the region.

Recommendations:

First of all: the unit should continue its very good work and openness towards new challenges. The unit has a good record of importing and developing advanced knowledge of industrial and/or societal value and this activity should be kept or expanded.

However, industrial advances are becoming more and more complex, and its is unlikely that the unit can support this in general at the highest level. Therefore, the unit should consider whether it could augment its activities by also becoming a facilitator of collaborations between local industry and scientific or technological experts at other national or international institutions. It may be that the unit is already taking this role, but this is not evident from the self-evaluation.

Furthermore, it could of importance for the unit to establish more formal collaborations with similar institutes at the national, Nordic, or European level.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Empirical Software Engineering in Software, Systems and Services (M3S), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 14

RU Leader:
Oivo, Markku

Professors:
Isomursu, Minna – Kuvaja, Pasi – Mäntylä, Mika – Oivo, Markku – Päivärinta, Tero

Other PIs:
Liukkunen, Kari – Markkula, Jouni

Academic Staff in 2019	46
Professors	5
Senior Researchers	4
Postdoctoral Researchers	12
Doctoral Students	22
Researchers on Personal Grant	0
In Teaching only	3
Of these:	
Principal Investigators	7
Docents (Adjunct Professors)	9

General description of the RU

M3S combines professional software engineering (SE) with exploring the possibilities of digitalization through new innovative systems and services. We are the largest SE research unit (RU) in Finland and among the key contributors in the European and in the global SE research community. Our research has a strong tradition in empirical SE research. During the last decade, we have made strategic efforts to build competencies that complement our world-class SE research with the exploration of SE in selected domains addressing global challenges (i.e., health and cyber-physical systems [CPSs] and services).

M3S has ongoing collaboration projects with leading software companies in Finland and Europe and a proven track record in making a high impact in industry and society. The unit has been successful in attracting international talents and growing into close to 60 members, including professors, lecturers, postdocs, Ph.D. students, research assistants.

Current description of the RU (rating 6)

The RU is a world-class software engineering group with strong international impact and also a strong emphasis on forming the next generation of software engineers. The RU had and continues to have a very strong research record and impact in the scientific community distributed over many societal challenges and application fields. The RU works both on theoretical and experimental aspects of software engineering and has contributed a lot in the past at the forefront of the following topical areas: health software and the development of high-productivity development tools.

The RU has successfully broadened in the last years their research on software engineering methods with their specialisations in relevant application domains like automotive industry, production automation and healthcare.

The RU's publication output is of excellent quality and reflects the productivity of the RU team. The numerous awards and positions in rankings, the successful acquiring of highly competitive external funding attribute to the very strong position and influence of the RU members. Participation in large-scale national and international projects has led to close ties with international and Nordic countries' researchers. The RU is very active and partly leading in relevant international research communities like the ISERN; members of the RU hold positions on editorial boards and as associative editors in some of the top journals in Software Engineering.

Future potential of the RU (rating 5)

The strategic vision formulates a path where the traditional and high-level empirical software engineering research is complemented by a focus on specific application areas. Health care IT, AI applications, and automotive systems can be expected to challenge the core of software engineering.

The stragegy though only in the last part points to possible synergy between the Software Engineering core (3.1) and application domains (3.2). Here, the strategy lacks to develop the potential of the broadening of the RU's focus during the last years. Topics like software and data ecosystems, continuous software engineering, or the interaction between co-design and software engineering could be starting points for such a discussion.

Otherwise, the RU presents ambitious plans for the next years, which look very feasible given its excellent track record. The objectives are very clearly described and measured against societal challenges.

They perfectly fit the Oulu strategy, continue to be of decisive societal impact, and will certainly lead to first-class research. In addition, spin-offs and researcher education goals are defined, which will serve indirectly both society and industry.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The RU is a world-class software engineering group with strong international impact.

The RU is leading in relevant international research communities.

The RU handles the interaction with society as a strategical asset.

Strengths:

- Long-standing international visibility and leadership in the international SE community.
- Strong track record in attracting national and European funding.
- Complementing core software engineering research with research related to application domains

Development areas

- Creating synergy between software engineering core and the SE research related to targeted application domains like Health care IT, AI and automotive systems.
- Some of the newer themes as software and (a more recent topic) data ecosystems or continuous SE seem to be under represented in the research of the group.

Recommendations:

The RU could gain from explicit addressing the potentials in the synergy between software engineering core and the SE research related to the targeted application domains.

The RU might explore evolving themes in SE that are slightly outside the current competence fields to explore new directions.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Mathematical Sciences (MathSci), Faculty of Science
RAE2020 code: NSE 15

RU Leader:
Läärä, Esa (in 2019) – Sillanpää, Mikko
(at present)

Professors:
Hästö, Peter – Järvenpää, Maarit –
Läärä, Esa – Serov, Valeriy – Sillanpää,
Mikko

Other PIs:

Academic Staff in 2019	35
Professors	5
Senior Researchers	8
Postdoctoral Researchers	10
Doctoral Students	5
Researchers on Personal Grant	3
In Teaching only	4
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	9

General description of the RU

The RU conducts scientific research in the fields of pure mathematics, statistics and computational mathematics. Nowadays there is a globally recognized need for development of sophisticated mathematical and statistical tools for various purposes, including sustainability and environmental change. To quote former Vice-President of the International Mathematical Union, C. Rousseau: "addressing the climate change and sustainability issues requires the use and development of sophisticated mathematical tools. A concerted, massive, long-term involvement of the mathematical sciences in collaboration with other disciplines is essential to any significant progress in the understanding of planetary problems."

The pure mathematics research is concentrated on mathematical analysis with emphasis on fractal geometry. Fractals are objects in which almost similar patterns occur repeatedly at different scales and sizes. Phenomena with fractal features are encountered everywhere in nature and society. In applied mathematics the RU is developing methods connected to Bayesian hierarchical modelling, machine learning, clustering, distributed computation, network science and data-driven mathematical and statistical modelling.

Current description of the RU (rating 5)

The RU conducts scientific research in three classical fields of mathematics: pure mathematics (mathematical analysis with emphasis on fractal geometry), statistics (data-driven mathematical and statistical modelling) and computational mathematics (Bayesian hierarchical modelling, machine learning, clustering, distributed computation, network science).

Overall, their research profile is divided along pure and applied maths. The fractal geometry team is well known for its work on geometric measure theory, dynamical systems and random geometry, and has developed methods for solving a number of open problems related to these fields (e.g. 50 years old Furstenberg's conjecture was solved by the team; Suomala's work).

The overall influence of the RU is at high levels, in particular with a few members of the RU that are exceptionally strong. This includes their important contribution to e.g., i) solving a 50 years old Furstenberg's conjecture; ii) research on spatially independent martingal measures; iii) novel and powerful method to study the dimensional properties of random covering sets.

The multidisciplinary approach of the group of applied mathematics in the RU is indeed exceptional and can be seen as a highlight. Methods from statistics, numerical mathematics, optimization and machine learning are brought together and configure a mathematically driven hub for multidisciplinary research at OYO. The publications are very well perceived and in part highly cited.

Future potential of the RU (rating 4)

The RU intends to build upon previous long-term very successful research and also aspires to belong to the best-established teams in its fields as an entire RU. This latter is a realistic and reasonable aspiration.

The RU has integrated into the national strategy with their mid- and long-term research planning. Based on past performance and the evidence provided, it is most likely that the RU will remain at a similar and even improved level of national and international research and research training. For this, it may be advisable to build stronger EU funding portfolio and the RU may also need to spread out their portfolio in terms of age-profile (more young lecturers), and secure assurance from the Institution to recruit suitable succession.

In particular, the research plan is very well described in the self-report and the 8-point program. The points 1-5 corresponding to proposed research in the pure mathematics group formulate a concise plan based on the actual research profile. It cycles around Fürstenberg-type problems, the Dvoretzki covering problem and Olber's paradox. Breakthrough results in all these internationally known problems are expected to emerge from the group.

The applied mathematics group proposes, in points 6 to 8, to focus even stronger on high-dimensional methods involving statistics and numerical resolution. They build on the excellent expertise developed during the last evaluation phase. The group addresses exactly the right questions and has the potential to succeed to become a leading group in this area. It is the application driven linking between methods for inverse problems, multidimensional statistics and possibly optimization and control that is peculiar for the group, where a general emphasis on machine learning methods, as is often observed elsewhere, would lead nowhere.

The RU has provided evidence that they do have the vision, so it is recommended that this vision is in fact supported.

The RU has recognized that some of their research has important societal impact. The industry links may seem to be lacking, there is room for improvements.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Cutting edge results in the area of Furstenberg-type conjectures and spatially independent martingale measures. Multidisciplinary research in challenging application contexts, top third party funding in applied mathematics, in particular within the CoE Inverse Modeling and Imaging (HiDyn: Hauptmann PI)

Strengths and development areas:

Strength:

Pure mathematics: Worldwide highly regarded group in the field of fractal geometry, dynamical systems, ergodic theory, harmonic analysis.

Applied mathematics: Multidisciplinary approach including machine-learning, statistical modeling, inverse problems, machine learning, high dimensional computation in the context of real world applications.

Development areas:

Pure mathematics: Fractal geometry in the context of applications in science and engineering.

Applied mathematics: Integration of analytical and numerical methods with data science technologies in order to build real-time capable surrogate models for grand scale engineering applications

Recommendations:

More interaction with applications is strongly recommended, even though the research of the RU is valuable as it is.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Process Metallurgy (Met), Faculty of Technology
RAE2020 code: NSE 16

RU Leader:
Fabritius, Timo

Professors:
Fabritius, Timo – Louhenkilpi, Seppo

Other PIs:
Shu, Qifeng

Academic Staff in 2019	25
Professors	2
Senior Researchers	3
Postdoctoral Researchers	10
Doctoral Students	10
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	2
Docents (Adjunct Professors)	4

General description of the RU

The mission of the Process Metallurgy RU is to carry out research on metallurgical and other high-temperature processes and to produce diploma engineers and doctors, who understand and master the phenomena of high-temperature processes in the metallurgical industry. The research activities of the RU based on the understanding of reactions, reaction kinetics, thermodynamics and mass and heat transfer phenomena in high-temperature processes. These research actions contain all the individual unit processes of steelmaking onwards from raw material handling to continuous casting and reheating of steel slabs before hot rolling.

Current description of the RU (rating 6)

The RU focusses on clean steel making and is among the leading groups at least in Europe. The research areas include applied metallurgy, sustainable metallurgy and new treatment methods providing a good combination of conventional/industry focussed metallurgy and future/advanced metallurgy. The research methods are solid both methodologically and empirically.

Journal publication is traditionally weak in manufacturing with respect to journal metrics, so this aspect should not be overemphasized even though the RU performs well. Overall, there are very good collaborations with internationally leading institutes. Collaboration evidence involves research projects, joint publications and exchanges. Moreover, the RU is active in internal collaboration, e.g. MME and NANOMO – along with sensible links to sustainable chemistry, including educational aspects.

Future potential of the RU (rating 6)

The goal is to consider greener steels and more efficient production methods – this is in line with UN sustainable development goals. Clear target areas are identified that align well with the experience and skills of the RU, and facilities. There is a great potential for societal impacts in terms of environmental benefits, industry gains and employment.

Plans are clear and aimed at important advances in field in terms of sustainable steel, and circular economy. The feasibility is very good, as the RU starts from a very high level.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The RU is internationally visible and collaborating with the leading institutions in their field.

There has been a very successul strategic renewal.

The RU has achieved a substantial increase in the success rate in competitive funding.

Strengths and development areas:

The scientific action plan is clearly focused and very promising.

There is a clear leadership and communication within the unit.

Recommendations:

Very successful RU which is encouraged to continue as outlined.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY	6 CLEAN WATER AND SANITATION	7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	12 RESPONSIBLE CONSUMPTION AND PRODUCTION	13 CLIMATE ACTION	14 LIFE BELOW WATER
15 LIFE ON LAND	17 PARTNERSHIPS FOR THE GOALS			

Microelectronics (MIC), Faculty of Information Technology and Electrical Engineering
RAE2020 code: NSE 17

RU Leader:
Jantunen, Heli

Professors:
Jantunen, Heli – Kordas, Krisztian

Other PIs:
Juuti, Jari

Academic Staff in 2019	31
Professors	2
Senior Researchers	4
Postdoctoral Researchers	12
Doctoral Students	13
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	3
Docents (Adjunct Professors)	8

General description of the RU

The Microelectronics Research Unit (MIC) is part of the Faculty of Information Technology and Electrical Engineering of the University Oulu. Our research is focused on electronics materials and their applications. We provide education to the Degree Programme in Electronics and Communications Engineering with various courses and thesis topics in both Bachelor and Master levels.

The mission of MIC is to remain among the frontiers of heterogeneous micro- and nano-system technologies with internationally recognized research and education of practical values. In the previous RAE carried out in 2013, the Research Community (MtM, More-Than-Moore) coordinated by MIC, received score Outstanding 6/6. MIC is a multinational and multidisciplinary unit (https://www.oulu.fi/microelectronics/) with experts in physics, chemistry, materials science and mechanical, process and electrical engineering. Having over 40 years of experience in materials science (e.g. electroceramics, nanostructured materials) and technology (printing and lithography, composites and integration) as well as related applications (micro and nanoelectronics, actuating, sensing, energy, environmental and telecommunication technologies) the unit has established an excellent network of domestic and international collaborators in Europe, Asia and US.

Current description of the RU (rating 6)

The RU performs high impact research on electronic materials which have resulted in several major breakthroughs in the field. The general research area is microelectronics, covering materials development, synthesis (inc. low temperature synthesis), fabrication/design of devices, and integrated applications (on-chip systems including novel sensors, energy harvesting). The research is methodologically and empirically very solid and highly multi-disciplinary.

Overall publication metrics are competitive with journal publications being the primary route of output. Publications can be found in leading and prestigious journals in the area of materials and micro-systems.

The RU acquires funding both for fundamental research (Academy of Finland, recently very successful) and applications (EU and industry related). The range of areas is broad, ranging from fundamental materials design to device performance and device integration The RU is successfully spreading efforts across a range of sectors that can provide funding routes.

Future potential of the RU (rating 6)

The RU has developed a highly focussed and detailed strategy, with a high probability to produce signifcant results. 0Clear areas for focus are identifed, ranging from energy conversion and storage, sensors, comms, to integration and complex systems. Challenges for future research include lead free systems, piezoresistive sensors (linked to sensors and integration), novel materials, energy storage, new sensor

materials, low temperature processing, combined systems, demonstrator systems and in-field applications. These areas can also provide significant societal impact (greener processing, energy storage/generation).

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The RU has a strong track record of high-quality and cutting-edge research.

Multi-disciplinary research activities are performed in active research areas with great success.

The RU covers the complete chain from fundamental materials research to applications. This has lead to several breakthroughs in the field of electronic materials and devices.

Strengths and development areas:

The RU has identified future key areas in their field.

The RU has developed a systematic approach how realize their future goals.

The amount of external funding is impressive with a very good mix between basic research funding and projects in application.

Recommendations:

Very successful RU which is encouraged to continue as outlined.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

3 GOOD HEALTH AND WELL-BEING

7 AFFORDABLE AND CLEAN ENERGY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

Materials and Mechanical Engineering (MME), Faculty of Technology

RAE2020 code: NSE 18

RU Leader:
Kömi, Jukka

Professors:
Frondelius, Tero – Kömi, Jukka –
Larkiola, Jari – Niskanen, Juhani

Other PIs:
Somani, Mahesh – Kaijalainen, Antti

Academic Staff in 2019	46
Professors	4
Senior Researchers	3
Postdoctoral Researchers	4
Doctoral Students	35
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	5

General description of the RU

The activities of Materials and Mechanical Engineering Unit are particularly directed towards the research and development, design and processing of steels as well as their properties and applications. The strategy of MME is based on the high competence for sustainable advancement and production of high strength steels and steel products. The distinct vision "Steeling the Show" describes its ambition for the continuous innovation and development in this area. Hence, the strategic spearheads are steel research, thermo-mechanical processing of high strength steels utilizing physical simulation and modelling, advanced metallography and mechanical testing. In the near future, weldability, formability and design studies on steels will represent the second major activity. The equipment available in the laboratory consists of two thermomechanical simulators, a laboratory rolling mill, a wide range of mechanical testing machines as well as the metallography facilities. The extensive research work is performed in close co-operation with the Finnish and foreign universities and research institutes, along with the steel industry in Finland and abroad.

Current description of the RU (rating 4)

MME involves sustainable production to decrease greenhouse gases, circular economy, advanced steels, process modelling and high quality education. The impact is related to physical metallurgy with a focus on sustainable production – in particular in high strength steels and austenitic stainless steels. The research is very much based on requirements of industry. Most topics are fairly classical, but the general level is quite high.

The RU has a good publication record, but collaboration with industry limits publication activities. Hence these aspects are of limited importance in the field. The RU is very successful in industrial projects, but external funding from established institutions is comparatively weak. Long term industrial collaboration is present.

There is an impressive list of cooperation partners, but it is hard to judge whether these are just contacts, or if there is some ongoing joint work.

Future potential of the RU (rating 5)

There are some very ambitious goals, such as tripling the funding from Academy of Finland and EU. This may not be realistic, while on the other hand, the individual research goals look more like a continuation of present work. Future research areas include modelling, simulation, digitisation and virtual steel manufacture. The industry driven interactions and cooperation are aimed to continue. The future goals align well with societal and environmental needs and core skills of the RU, competencies and facilities of the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU has strong interactions and cooperations with Finnish steel industry and thus play a significant role in this important economic sector.

Strengths and development areas:

The RU covers the whole range of characterization both on the experimental and on the simulation side.

The equipment is modern and very well aligned with the needs of industry.

Cooperation within the RU works well and is beneficial in acquiring project funding.

Recommendations:

The RU has yet to develop a coherent long-term strategy. Clearly, joint projects with industry will continue to dominate their activities, but the goals on the side of fundamental science have to be more focussed.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Nano and Molecular Systems Research Unit (NANOMO), Faculty of Science
RAE2020 code: NSE 19

RU Leader:
Huttula, Marko

Professors:
Alatalo, Matti – Huttula, Marko – Thuneberg, Erkki

Other PIs:
Aho, Saana-Maija – Patanen, Minna – Silveri, Matti – Cao, Wei – Heimonen, Kyösti – Prisle, Nønne

Academic Staff in 2019	42
Professors	3
Senior Researchers	10
Postdoctoral Researchers	10
Doctoral Students	18
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	8
Docents (Adjunct Professors)	11

General description of the RU

NANOMO is a scientifically versatile physics RU with a wide funding profile and international staff. The RU is actively shaping, focusing and renewing science at University of Oulu (UO). Research includes electronic structure of nanomatter, atmospheric chemistry and physics, functional materials (steel, CO_2 negative materials, catalysts), biomedical research and mesoscopic quantum structures. RU coordinates national participation in the MAX IV synchrotron radiation (SR) facility and contributes to the European X-ray Free Electron Laser (XFEL). NANOMO collaborates in multidisciplinary projects with several RU's and faculties and is an important part of several focus areas of the UO and Academy of Finland (AF) funded profiling (PROFI) actions. The RU has several multidisciplinary projects in the UO as well as cross-sectorally outside the academia. The RU implements the UO strategy of excellent student experience, from daily student guidance to a research line on physics didactics. The RU enhances UOs high school relations, is partner in the national Climate University and implements the education from sustainability and cross sectoral perspectives.

Current description of the RU (rating 5)

The RU contains a quite diverse number of research directions in experimental and theoretical physics with the goal of building a sustainable future through the molecular understanding of materials and reactions. It relies of large-scale facilities such as MAX-IV for intense synchrotron radiation, free electron lasers and high-performance computers. The unit has a significant number of publications in top journals with a strong increase of visibility over the last years. Its members have extensive collaborations with national and international academic and non-academic institutions. It is funded by a very broad funding structure, including very competitive funding by ERC and the Academy of Finland. The research addresses many important societal issues, for instance through its studies of aerosols, of improved catalysts for hydrogen generation and for quantum computing. Its internal structure is well-balanced; it renews its membership on an increasingly international basis.

Future potential of the RU (rating 5)

The Scientific Action Plan is very ambitious, but also specific, such as in the field of photocatalysts, steel production with low carbon impact, or in quantum computing. These fields are of high future importance. The RU is well aware of the UN sustainable development goal and would, if successful, make a major step towards being a leading unit in its fields. Successful recruitment in the last years leading to a strong improvement of the recent track record support these goals.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU plays a leading role in the MAXIV synchrotron radiation collaboration.

Strengths and development areas:

The RU impresses by its output in high-quality journals, its broad funding base, its high international connectivity, and its emphasis of fields of high future impact, in particular in view of the university's sustainability goals. Its internal structure is very healthy, and it has been able to attract very dynamic new members over the last years. In terms of citations, the visibility could be somewhat higher; the number of excellent researchers might be still inadequate to achieve the very ambitious goals of the Scientific Action Plan. The loose management structure has served the RU very well in the past, but might not be able to deliver when the RU is pushed into the competition at the highest international level.

Recommendations:

The RU should consider how it could improve the visibility of its publications which already appear in top journals, but do not yet exploit the associated citation potential. In order to achieve its future goals, the RU will have to accelerate its successful policy of hiring experienced researchers and young talent. It might consider replacing its current (very admirable) loose management structure by more prioritization of goals to achieve its very ambitious goals.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

NMR Research Unit (NMR), Faculty of Science
RAE2020 code: NSE 20

RU Leader:
Vaara, Juha

Professors:
Telkki, Ville-Veikko – Vaara, Juha

Other PIs:
Kantola, Anu – Lantto, Perttu – Zhivonitko, Vladimir

Academic Staff in 2019	22
Professors	2
Senior Researchers	3
Postdoctoral Researchers	8
Doctoral Students	8
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	5

General description of the RU

Nuclear Magnetic Resonance (NMR) spectroscopy is one of the most powerful methods in materials and chemical analysis. The NMR Research Unit develops and applies advanced experimental and computational NMR methods for materials research. We focus on increasing the sensitivity, information content and efficiency of NMR, and exploit the methods in novel applications, such as sustainable cement, porous adsorbents, catalysts, aerosols, exosomes and biosensors. The experimental methods include ultrafast Laplace NMR, which allows single-scan multidimensional relaxation and diffusion experiments to study molecular dynamics, parahydrogen-induced polarization for hypersensitive, non-toxic NMR sensors of materials, catalysis and biomolecules, as well as the entirely new nuclear magneto-optic spectroscopy, which relies on optical detection of nuclear magnetization. Computational methods comprise multiscale modeling of entire experiments combining molecular dynamics simulation and spin Hamiltonians obtained by quantum chemistry, used, in turn, to drive spin dynamics, theory of paramagnetic NMR and modeling of materials NMR parameters.

Current description of the RU (rating 5)

The overall goal of the research is the development of improved methods for performing NMR experiments and extracting information from these experiments. By combining theoretical and computational insight with a deep understanding of the current generations of NMR spectrometers, cutting edge research is performed with the purpose of developing hyperpolarization NMR, fast Laplace transform NMR, and combined optical-NMR methods. Within all these fields, the research performed at the unit is certainly excellent and is at or near the highest international level.

A successful outcome of the research can be exploited in a number of important scientific disciplines, including for example health sciences material science, and thereby become an important contributor to the solution of many problems of great societal impact.

The RU has by its success in attracting very competitive and prestigious funding (in particular a ERC Consolidator grant), publishing creative and original research in high-impact journals, demonstrated that it provides academic leadership at a high international level within the field.

Future potential of the RU (rating 6)

The unit has a very concise stated vision for the future: in six years it aspires to be one of the world-leading groups in NMR methods for material research. The current lines of research are ambitions and are in line with the overall goal. The scientific goals do not envision completely new paradigms, but rather to bring its methodological advances to full fruition, opening up new applications of NMR which should have high impact e.g. in climate research and materials development. The research in NMR instrumentation and the further development of theoretical and computational methods are cutting edge research, and there is

as such the risk that some of the research lines will not produce the intended outcome. However, these risks are in line with the potential gains.

The research activities address important goals for a sustainable future including a carbon-neutral society, good health and well-being.

The successful realization of the scientific action plan involves the expansion of the unit from 20 to about 30 members. Such an expansion depends on continued and probably increased support from the regional, national and European grant agencies, as well as from Oulu University. It is noted that the unit is planning to apply for a centre of Excellence. A successful realization of the research goals does not require that the unit shift research focus, but rather that several of the current and developing research lines have a successful outcome.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

The research into the development of improved forms of NMR spectroscopy, including hyperpolarization methods and Fast Laplace transform NMR, as well as combined optical-NMR methods, constitute state of the art research in a very important and competitive field.

Strengths and development areas:

The strength of the research unit is the presence of top-notch researchers within the experimental as well as the theoretical/computational aspects of NMR spectroscopy. The recent addition of a new research line in molecular magnetism is in line with the international developments in the field of magnetism.

Recommendations:

Taking a promising experimental method into a method of general use and acceptance is a very demanding undertaking. This general observation certainly holds for the current and planned developments of the NMR research unit. The unit should therefore carefully consider to which degree it wants to expand into new and promising fields, such as molecular magnetism, and to which degree it wants to strengthen the effort to ensure a successful outcome of one or more of the well-established research lines.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Oulu Advanced Research on Service and Information Systems (OASIS), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 21

RU Leader:
Oinas-Kukkonen, Harri

Professors:
Oinas-Kukkonen, Harri – Pulli, Petri

Other PIs:

Academic Staff in 2019	11
Professors	2
Senior Researchers	1
Postdoctoral Researchers	3
Doctoral Students	5
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	2
Docents (Adjunct Professors)	2

General description of the RU

Use of modern information and communication technologies in our everyday lives have opened up a wide variety of opportunities for influencing people's behaviors. For instance, fostering healthier lifestyles through the web or mobile applications has become a key area for health improvement. This is possible because information systems maintain powers to motivate users to set goals and encourage them to adopt a desirable target behavior. Psychologically the key is attitude or behavior change, and the design of successful technological interventions stems from understanding how and to what extent users can and should be persuaded. These persuasive systems are computerized software or information systems designed to reinforce, change or shape attitudes or behavior or both without using coercion or deception. Positive user experiences and proper level of engagement are important in this. Our key application domain is health. Digital health interventions have already become quite common and promising health outcomes results have been achieved, but it still remains open what really works in these interventions, for whom, when, how and ultimately why.

Current description of the RU (rating 5)

The RU pursues creative and original research program in the intersection of information systems, behavioral science and health. Persuasive technology, where the RU's main activity belongs to, is a very attractive research area. The RU is focuses almost entirely on a specific approach developed by RU leader some time ago.

Research takes place in cooperation with medical researchers and hospitals. To address the needs of the different disciplines the research applies a wide set of methods reaching from design research, experimental design, to randomized trials.

The RU's publication output is of excellent quality and reflects the productivity of the RU teams. Most of the publications listed have been published in top international journals and international peer-reviewed conferences.

The RU has a very good research position and impact in the field. The researchers of the RU have been taking active role in international and national research activities through participation in large scale national and international projects. The RU benefits from the outstanding role of the RU leader who holds editorial positions relevant to the research field of the group.

Future potential of the RU (rating 4)

The RU has a clear and very ambitious scientific goals for the next couple of years, which will result in an improved position within the scientific community. The scientific plans are essentially centralized around the specific design approach developed by the RU leader, which is considered critical, due to the dependence on this one topic. As new developments, collaboration with Oulu's 6G flagship project, and

research addressing ethically problematic aspects of persuasive technology are mentioned. Overall, the vision is rather conservative.

The future research objectives are very clearly described and measured against societal challenges in the health sector. The RU has defined its goals along the University strategies and plans are made to increase the groups size twofold. The strategy is well founded in ongoing research projects and can be reached if additional personnel and innovation enter the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

Successful research on behaviour change through persuasive technology.

Collaboration with medical researchers and hospitals.

Breadth of research methods applied: from design research to controlled clinical trial.

Strengths:
- Established design methodology
- International recognized in the area of persuasive technology

Development areas:
- Much or the RU's activity depends on the research leader.
- The research focus is rather narrow leaving little room for young researchers to establish themselves.

Recommendations:

The main challenge for the research unit is to define a broader focus that allows the younger faculty in the RU to develop their own profile.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Oulu Mining School (OMS), Faculty of Technology
RAE2020 code: NSE 22

RU Leader:
Luukkanen, Saija

Professors:
Kozlovskaya, Elena – Lunkka, Juha Pekka – Luukkanen, Saija – Strand, Kari – Zhang, Zongxian – Yang, Shenghong

Other PIs:

Academic Staff in 2019	27
Professors	6
Senior Researchers	3
Postdoctoral Researchers	4
Doctoral Students	13
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	8

General description of the RU

Oulu Mining School (OMS) is one of the research units (RU) in the Faculty of Technology. It was established in 2014 to carry out research and provide education in the mining-related core areas: geosciences, mining engineering, and mineral processing. Nationally and internationally, OMS is a unique research and educational institute compared to mining or geoscience institutes elsewhere since it combines a wide range of geoscience and engineering disciplines. This combination of disciplines provides an excellent platform to carry out versatile and comprehensive research of raw materials and their sustainable use in mining operations. Oulu Mining School is the only mining school in the European Nordic countries.

The main aims of the research in OMS are to investigate geological systems and sustainable beneficiation of Arctic mineral resources and to unlock the mineral wealth of the Arctic to the avail of the local population as well as stakeholders in government, industry and education. Integrated research facilities in geosciences and engineering provide a unique multidisciplinary platform to solve scientific and societal challenges in the mining sector.

Current description of the RU (rating 5)

The members of the RU are well recognized scientists in their field of research. It is worth noting that they have demonstrated geographic mobility, which is not very common for most RUs at the University of Oulu.

The research conducted at the combines different expertises and aims to integrate scientific disciplines along the value chain from optimized exploration to sustainable mining and mineral processing. The RU is actively engaged in collaborations, internationally, nationally and internally within the University of Oulu. It is a core partner in the EU-EIT Raw Materials innovation hub CLC Baltic Sea and other programs and consortiums. The members of the RU collaborate with relevant partners in their fields. These collaborations are facilitated by the large spectrum of expertise that can be found in the RU. Active collaboration is also engaged with the major mining and mining technology companies operating in Finland. The activities of the RU are well connected with the research community on "geological systems and Artic mining" and with the Kvantum institute. It is supportive of high quality research.

The RU is a member of several national and international consortiums and programs. The RU members have a strong collaborators network. They actively collaborate with other RUs from the University of Oulu and several domestic companies. The visibility of the RU is very good.

It is a unique RU in European Nordic countries with a short history and it has the potential to have a strong impact on mineral exploration in the Artic region. The RU considers important aspects of sustainable use of mineral resources, circular economy and global change. It is strongly involved in the development of

mining industry in the Artic region, contributing to business opportunities and infrastructure development, which can have possitive effects on local communities. Protection of biodiversity, reduction of the amount of mining-produced waste and sustainable practices are also considered. The societal impact of the activities of the RU is therefore strong.

There have been significant changes in the research focus areas and major organizational modifications in the RU during the last years. These facts have a strong impact on the scientific production of the RU and the current research focus areas are not fully represented in the bibliometric data. A substantial increase in the number and quality of publications is observed and it is expected to continue with the achievement of the critical mass of personnel involved in research.

The research funding is good, but evolutive considering the significant recent changes in the research focus areas and major organizational modifications. The achievement of the critical mass of personnel involved in research and the broad range of expertise of the RU are encouraging signs of an increase in the amount of external funding in the near future. Opportunities are important, especially from Nordic stakeholders. Effective interdisciplinar collaborations with other RUs within the University of Oulu are established and promoted by the Faculty of Technology. The RU belongs to the research community on "geological systems and Artic mining" and participates to two spearhead projects coordinated by one of the four focus institutes at the University of Oulu (Kvantum Institute). The RU is very well equipped for its different research activities and the infrastructure strongly supports high quality research. Advanced instruments can be accessed through membership in different infrastructures. An in-house, continuously operating pilot plan for mineral processing is available in the RU.

The close collaboration in the Artic region should promote mobility among the Nordic countries. Postdoctoral researchers and PhD students have opportunities to visit collaborators. There are currently 13 PhD students and 4 postdoctoral researchers in the RU. These numbers are relatively low considering the number of professors and senior researchers (9). The PhD students participate in teaching and also supervise MSc students. Teaching in the RU is closely linked to research and industry-supported practical training. Through the network of collaborators of the RU, external professionals are invited to give lectures and short courses in their respective fields of expertise.

Future potential of the RU (rating 5)

The RU realizes the societal impact in its work and intends to concentrate its future research on assessing, strengthening, and mitigating resource and infrastructure systems against the effects of global environmental and climate change, particularly in the Arctic region. These scientific objectives for the future are clearly described and in the continuation of the works already engaged. The multidisciplinarity of the RU is a strength to support the sustainable use of primary raw materials with reduced environmental impact and circular economy-based research at the University of Oulu. The scientific objectives are perfectly in line with the Faculties' strategies and UN sustainable development goals.

The future research goals appears realistic as they are based on ongoing actions and a strong network of partners. To date, the research funding is good and does not come from a single source, which ensures the viability of the RU.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

The RU has international recognition and has a well-established interaction with other research groups.

The RU gathers personnel with large range of expertise which allows to address issues on many societal topics.

Strengths and development areas:

The multidisplinarity of the RU is excellent.

The RU is well equipped and has access to larger equipment when needed.

The financial support is good.

The RU covers research projects from fundamental up to applied sides.

The RU research activities are perfectly integrated in its environment.

Recommendations:

Many changes occurred in the RU with recent reorganization. Careful attention is needed to maintain consistency of the RU.

The number of postdoctoral researchers and PhD students is relatively low considering the number of professors and senior researchers. It has the potential to be increased.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Opto-Electronics and Measurement Techniques (OPEM), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 23

RU Leader:
Fabritius, Tapio

Professors:
Fabritius, Tapio – Meglinski, Igor

Other PIs:
Mäkynen, Anssi – Bykau, Aliaksander

Academic Staff in 2019	23
Professors	2
Senior Researchers	2
Postdoctoral Researchers	8
Doctoral Students	11
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	4
Docents (Adjunct Professors)	6

General description of the RU

OPEM performs optoelectronics and measurement techniques research in a multidisciplinary environment from engineering, physics and chemistry. The research unit is developing optics and electronics components and systems. OPEM has expertise and infrastructure to fabricate optics and optoelectronics (OLEDs, detectors, solar cells, passive optics) starting from the raw materials including nanoparticles, quantum dots etc. and ending at the complete tomography and imaging systems. The specific fields of expertise of OPEM are the printing-based fabrication of optoelectronics, industrial and medical measurement techniques and biophotonics.

Current description of the RU (rating 5)

The RU has a strong and innovative research portfolio supported by large infrastructure funding. The focus on biomedical and printing methodologies and application fields has allowed the group to prosper and the group is top situated in the scientific community with excellent funding. The research pursued by the RU is methodologically solid and reflected in frequent high quality publications. The research lines focus on research topics of great originality. The members of the RU are well recognized scientists and top rank in Finland. The bio-related research is considered very successful. The newly acquired infrastructure project FiRI will help to establish a second strong line of research.

The RU's academic interaction is highly structured and organized in support for high quality of research. The RU has excellent research funding strategies including separate strategies for the individual groups and national as well as international research projects, respectively. The RU has a strong participation of female researchers, which is exceptional in engineering. The RU contributes to societally relevant projects in the areas of Health, Energy, and Advanced Manufacturing.

The RU's publication output is of very high quality. Considering the amount of funding available and the structure of the group, the RU publication output can be considered very good and competitive among other RUs. The RU is cooperating intensively with top national and international research groups.

Future potential of the RU (rating 4)

The RU has a clear and ambitious scientific goals and is currently on a route of success, which it wants to pursue further. The research objectives are stated very clearly with quantitatively measurable goals. The monitoring of the evolution of the research within the RU is very detailed. The goals set for the next 3 – 5 years by the RU are realistic and feasible.

The field of research has been rather experimental and only recently the RU started to work on metamaterials, which are compatible with the group's technological expertise. This demands for new cooperation networks within other groups in Finland and on international level. This brings a risk in fully exploring future potential.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

- The research infrastructures of the RU is excellent and is supported by large-scale projects such as FiRI.

- The research areas cover important societal aspects within the biomedical and printing methodologies

- Research covers areas from material science to tomography and imaging systems

Strengths and development areas:

- Given the strong technological foundation of the RU the visibility is still increasing.

- The recruitment strategy in the RU, especially the female talented researchers, lack promotion paths

Recommendations:

The field of research has been rather experimental and the recent work on metamaterials could experience a lot of competition from other groups in Finland and internationally.

The RU has strong ties with industry and hence an excellent cooperation with business life including spin-offs, which could be exploited for novel areas of research.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Oulu School of Architecture (OSA), Faculty of Technology

RAE2020 code: NSE 24

Primary panel: Natural Sciences and Engineering
Secondary panel: Culture and Society

RU Leader:
Pihlajaniemi, Janne

Professors:
Hentilä, Helka-Liisa – Mahlamäki, Rainer – Outila, Tarja – Pihlajaniemi, Janne – Sanaksenaho, Veli-Matti

Other PIs:
Herneoja, Aulikki – Soikkeli, Anu – Hirvonen-Kantola, Sari – Pihlajaniemi, Henrika

Academic Staff in 2019	20
Professors	4
Senior Researchers	3
Postdoctoral Researchers	2
Doctoral Students	9
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	7
Docents (Adjunct Professors)	7

General description of the RU

Oulu School of Architecture is one of the 12 research units of the Faculty of Technology. The focus area of the research is the 'Changing Northern Built Environment'. The research is conducted in three research groups: Cultural Transformation, Smart City and Smart Architecture and Construction. The research of OSA is interdisciplinary and connected to the focus institute Kvantum, supporting the University's strategic focus areas- Sustainable materials and systems and Changing climate and northern environment. Moreover, due to the interdisciplinary nature and practice-oriented approach of OSA's research, many PI's also have continuous and active collaboration with e.g. Faculties of ITEE, Humanities, Oulu Business School and numerous other national and international universities and research institutes, in addition to cities, communities, industrial partners and other non-academic collaborators.

Current description of the RU (rating 4)

The faculty at the Oulu School of Architecture (OSA) conduct rigorous and creative research that is making significant impacts on the field, with key strengths in the area of understanding the relationships between the changing physical and socio-economic environment of high latitude regions and the future design and functioning of the built environment. The OSA focusses its research activities on a very suitable and timely theme: the Northern Built Environment. This includes topics such as sustainable winter cities, smart cities, and the cultural heritage of the North. Despite recent efforts and achievements, architecture as a discipline and OSA as a research unit do not have a strong tradition of scientific publications.

The RU has built a broad set of research methods over time, including design and participatory approaches (following a paradigm shift away from laboratory research). This is a promising path, despite potential short-term pushback within parts of the more traditionally oriented/less open research communities. However, this issue reflects the conflict that any school or architecture within a university research environment is facing. The academic contribution of particular creative research outputs not reflected in traditional publication records, while valuable to advancing the field, are difficult to assess.

The RU has an average annual competitive research funding of 229k EUR. More than 20% of this budget come from international sources. The international funding includes a five-year H2020 EU project on energy efficient pathways for the transformation of cities. The national funding includes three Academy of Finland projects. Their strategy is to increase their international funding as well as funding from the Academy of Finland.

There are certainly plentiful collaborations within Finland, and many between members of the OSA faculty. The RU has a broad network of collaborators across national and international universities and research institutions. The RU has a range of relevant non-academic partners within its network. This is one of the strengths of this RU.

The RU has some infrastructure elements to support its projects, mainly to test elements in real-world interventions. These infrastructure elements appear useful and appropriate for the research objectives of the RU.

Future potential of the RU (rating 4)

The RU has ambitious and innovative ideas for their future work and has definitely considered the University's and Faculty's goals as well as the UN goals. The RU has an interesting research agenda with themes that have high societal value. The Action Plan is good in referencing clear areas of research: the Northern Built Environment, Smart Cities, and Smart Architecture. The RU is well positioned to make important contributions to designing sustainable cities in Arctic regions, a goal of the Arctic Interactions and Global Change strategy, as well as furthering the understanding and use of Arctic traditional architecture.

The research group Smart City will continue their work in analyzing and developing better ways to manage the complex web of technology, design, and land-use planning that is necessary for creating sustainable cities, thus helping urban populations become more resilient in providing adequate services and spaces. The Smart Architecture and Construction group is working toward three important goals. First, how the use of massive wood in the built environment can assist industry and create more sustainable building materials. Second, how work environments can be improved in terms of health and productivity. And third, how lighting strategies can promote a healthier environment. All of these goals are directly relevant to society since they create better environments for people. The RU's evaluation thoughtfully considers the challenges ahead.

The RU aims to increase the share of international funding (in particular, European funding) and high-quality funding (in particular, Academy of Finland). Furthermore, the RU emphasizes the increase of scientific publishing in terms of quantity and quality as well as in reaching a critical team size. Even though the RU does not quantify its objectives (e.g. by quantifying how much improvement in publications they aim to achieve), the goals appear ambitious and suitable.

Members of the RU seem will aware that they will need to devote more time and energy on publishing their work in top scientific journals, and on prioritizing the role of research. However, it is important to point out that much of what the RU produces is of a creative nature, and the 'output' is not an article, but, for example, a design for a better-lit room. There needs to be an understanding that creative outputs are important in and of themselves, and also -- since much of that creativity has direct societal impacts in the form and design of new and better environments -- those creative outputs make critical additions to the betterment of the human community at large. So, while we believe the plan is feasible, we would hope that the focus on scientific research does not outweigh the focus on design and creativity. In addition, the heavy teaching load of most members of the RU takes away time from their research and creativity. This might be a problem in terms of increasing research activity. The recognition by the members of the RU of their joint future goals and of the possible 'risks' associated with these goals shows that they are self-reflective about who they are and where they want to go, a very good sign for their future viability.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The RU looks into the future design of cities – this has a highly relevant impact on society. The RU's research activities build around real-world cases, such as adaptive and intelligent lighting, urban planning, or massive-wood architecture. These insights have impacts not just in Arctic regions but internationally as well.

One particular highlight is OSA's engagement with the broader community. Each of the architects is involved in exciting, real world projects related to the RU's core missions - ranging from sustainability to massive wood architecture, to smart cities and smart architecture. The sorts of shared projects sustained with communities and private interests is quite impressive and looks to be at the core of unit activity.

The team appears to work in a very collaborative manner. The research culture within OSA and the collaborations with the other RUs at Oulu, in particular the Faculty of Technology, are designed in a supportive way.

Strengths and development areas:

The number of academic publications has risen – both in quantity and quality. However, despite trending in the right direction, this remains a development area of the RU (and the discipline in general).

The OSA has a strong funding culture (they were involved in more than 130 funding applications between 2015-19). Most of the funding comes from Finnish sources but the OSA also has a major grant from the European Union. The EU grant may allow for more international collaboration in the future.

There is limited diversity in terms of education and background within the team (most team members have received their degrees from Oulu). While this might encourage the strong collaborative culture within the RU, it hinders efforts to increase the international collaborations of the RU.

Recommendations:

1. Increase of international mobility and collaboration: Nearly everybody at OSA has received their degrees from Oulu. Furthermore, while the collaboration within OSA seems to be robust, there is an opportunity to expand the RU's collaboration network, in particular internationally. Therefore, we believe that the RU would benefit from more intense international collaborations and – if possible – international recruitment.

2. Emphasis on scientific output/ academic publications in combination with a more balanced set of evaluation criteria: The rising importance of academic publications applies to architecture as a discipline and the OSA team has responded to this by increasing their emphasis on producing the required type of scientific output. However, their outputs also include more creative and practical contributions. While we encourage the efforts to increase the quality and quantity of the academic publications further, we would like to emphasize the need to find a more balanced set of criteria to evaluate the quality of research of a RU like OSA.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

No connection reported.

Structures and Construction Technology (SCT), Faculty of Technology
RAE2020 code: NSE 25

RU Leader:
Heikkilä, Rauno

Professors:
Heikkilä, Rauno

Other PIs: -

Academic Staff in 2019	19
Professors	1
Senior Researchers	2
Postdoctoral Researchers	2
Doctoral Students	12
Researchers on Personal Grant	0
In Teaching only	2
Of these:	
Principal Investigators	1
Docents (Adjunct Professors)	4

General description of the RU

Structures and Construction Technology Research Unit (SCT) is one of the ten research units of the Faculty of Technology at University of Oulu. The SCT Research Unit is focused on the design of large machinery and vehicles, various equipment, demanding engineering structures in buildings and bridges, construction technology, as well as applied mechanics in the fields of civil and mechanical engineering. The SCT unit participates in education at all levels (bachelor, master, doctoral) especially in the degree programs of civil engineering and mechanical engineering. The course topics cover engineering mechanics, structural engineering, indoor air and building health, transport engineering, geotechnical engineering, as well as building information modelling based construction automation and robotics.

Current description of the RU (rating 2)

The RU has been founded in order to develop a new MSc. in Civil Engineering and automation. Several senior members of the group have been hired only recently. The RU is still on its way to find its strategy with respect to funding.

The RU consists of 5 very heterogeneous research groups and is yet to develop a common profile. A common denominator could be the use of Building Information Models to model the constructions as a reference point for the automation both with respect to indoor climate management and automation of construction equipment e.g. an autonomous excavator. Some of the senior RU members seem to be extremely well established and world leaders in their area of expertise (e.g. indoor climate management), others are still new in research and seem to still need to find their footing in the international community.

All senior RU members engage in cooperation with industry and support of public agencies in each their respective area of interest and expertise, in parts also on an international level (UN). Several of the senior members of the RU have a background in industry.

Future potential of the RU (rating 3)

The strategy consists of a set of group specific strategies. The scientific action plan is not supported by previous work, which might be due to the fact that some of the research fields will be developed by recently appointed researchers. Rigth now, the future research goals are not realistic.

To bootstrap international competitive research, the RU might map out relevant research environments targeting similar research and work on strategic partnerships.

Highlights, strengths and development areas, recommendations and overall rating (3)

Highlights:

The RU addresses problems in the intersection between civil engineering, mechanical engineering and Computer Science.

Strengths and development areas:

Individual researchers have a strong, international track record.

There is a possibility to use the cooperation with industry as leverage for research.

Recommendations:

To bootstrap international competitive research, the RU might map out relevant research environments targeting similar research and work on strategic partnerships.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Sodankylä Geophysical Observatory (SGO), Regional Unit
RAE2020 code: NSE 26

RU Leader:
Turunen, Esa (in 2019) – Tanskanen, Eija
(at present)

Professors:
Lehtinen, Markku – Usoskin, Ilya –
Verronen, Pekka

Other PIs:
Ulich, Thomas – Kero, Antti –
Silvennoinen, Hanna – Kozlovsky,
Alexander – Manninen, Jyrki – Raita, Tero

Academic Staff in 2019	19
Professors	2
Senior Researchers	7
Postdoctoral Researchers	5
Doctoral Students	5
Researchers on Personal Grant	0
In Teaching only	0
Of these:	
Principal Investigators	8
Docents (Adjunct Professors)	10

General description of the RU

Established in 1913, Sodankylä Geophysical Observatory (SGO) carries out continuous, long-term observations of our near-Earth space environment and seismic activity as well as related research. SGO operates at more than 20 locations in Finland with some instruments located in Sweden and Antarctica. SGO is an independent unit of the University of Oulu, and the Observation Programme is a National Task. Beginning with measurements of Earth's magnetic field, SGO has steadily grown to become one of the most versatile observatories of the northern high latitudes, being located under the auroral oval, where space weather effects on our environment are particularly strong.

Today, SGO's core observations include vertical soundings of the ionosphere, measurements of galactic cosmic rays, a network of seismometers, measurements of cosmic radio noise absorption in the lower ionosphere, and two very popular auroral all-sky cameras. The observatory's measurements are usually part of international networks and operate at or above the standards set by them. Furthermore, SGO operates a number of guest and research instruments together with a large number of national and international collaborators and is heavily involved in the further development of its instruments. While SGO is not part of a faculty and does not offer university courses, SGO hosts and supervises students doing their thesis work at all academic levels. SGO's scientists are involved on individual basis in education at the main university campus as well as other universities. SGO organises international research schools, most prominently the EISCAT Radar School, as well as international conferences. SGO hosts the incoherent scatter radars (ISR) of the EISCAT Scientific Association in Finland. EISCAT is currently building EISCAT_3D, the most advanced ISR in the world, and SGO leads the infrastructure project for the construction of the Finnish radar site. Located in central Finnish Lapland, SGO supports regional development and collaborates, e.g., with the Municipality of Sodankylä on development of school education. SGO has established the Centre for Arctic Geoinnovation in order to bring together scientists and businesses.

Current description of the RU (rating 5)

The RU has developed a number interesting research outputs (e.g., the seasonal variations due to the solar wind composition; the close relationship of the mesospheric ozone and pulsating aurora). SGO belongs to the some of the best units performing this important line of research.

Overall, their research profile is traditionally about carrying out continuous, long-term observations of the near-Earth space environment and seismic activities. In particular, SGO's core observations include vertical soundings of the ionosphere, measurements of galactic cosmic rays, a network of seismometers, measurements of cosmic radio noise absorption in the lower ionosphere, and two very popular auroral all-sky cameras. These activities are threefold, and a highlight is the CHAMOS project. Anther excellent output is lead by Tanskanen on the seasonal variations due to the solar wind.

The methodological approaches are mostly at technical/observational levels. Theory may not be in the focus of this RU's activities. SGO has a very good production of good and high-quality papers in good international journals, with some true occasional highlights. The overall influence of the RU is at medium levels, but there are a few members of the RU that are exceptionally strong. This includes, e.g. their important

contribution to EISCAT, FIN-EPOS. Being an RU based on geophysical observations, the funding of the activities at SGO differs from that of many research units at a university. The RU has generated through their leading or contributing involvements considerable national and international funding.

Most members of the RU are involved in national (e.g. Helsinki) and international collaborations, some highest levels (MIT Haystack Observatory and University of Central Florida, EPOPS). The RU's Observation Programme serves as a great platform for research and guest instruments, which then usually means that SGO scientists take part in the use of the data and/or development of the instruments, resulting in numerous collaborations.

Future potential of the RU (rating 4)

The RU intends to build upon previous long-term successful research and also plans to benefit from ESA's SSA programme. This latter is a particularly important direction, given the strategic R&D of Horizon Europe. The RU has integrated into the national strategy with their mid- and long-term research planning.

The RU's strategic visions and plans are ambitious with the potential of high societal impact. An excellent future plan is to get directly involved in the European Union's Space Surveillance and Tracking program (EU/SST) that would be a real boost for the RU. The strategic vision contains five specific goals, which all are relevant and important. One of the stated goals may be important at the global scale: to obtain a drastically improved understanding of the how processes in the upper atmosphere drive lower atmosphere dynamics and impacts environmental changes. The suggested research will also lead to improved understanding and possibilities for warnings for strong solar storms and their effect on all digital equipment and communication.

Based on past performance and the evidence provided, it is most likely that the RU will remain at a similar level of national and international research and research training. For this, it may be advisable to have stronger links with SpaceAstro and the RU may also need to spread out their portfolio in terms of age-profile, and secure assurance from the Institution to recruit suitable succession.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

CHAMOS project.

Another excellent output is lead by Tanskanen on the seasonal variations due to the solar wind.

The RU is an important data provider for scientific research globally.

Strengths and development areas:

Development areas:

- increase of publication output.

- increase the international visibility of the RU

Recommendations:

Expand in the area of Theory in order to have a wider range of skills and support of the current methodologies.

Spread out expertise and recruit a nr of early-career researchers with high profile to guarantee sustainability and continuity.

Engage with European (Horizon Europe) programme, in particular ITNs towards securing the next generation of scientists

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Space Physics and Astronomy (SpaceAstro), Faculty of Science

RAE2020 code: NSE 27

RU Leader:
Aikio, Anita

Professors:
Aikio, Anita – Mursula, Kalevi – Oyama, Shinichiro – Salo, Heikki – Schmidt, Jürgen – Usoskin, Ilya

Other PIs:
Asikainen, Timo

Academic Staff in 2019	34
Professors	6
Senior Researchers	3
Postdoctoral Researchers	11
Doctoral Students	13
Researchers on Personal Grant	1
In Teaching only	0
Of these:	
Principal Investigators	6
Docents (Adjunct Professors)	11

General description of the RU

Research in Space Physics covers both the long-term (´space climate´), and short-term (´space weather´), variations in solar activity and their effects on the near-Earth space, the Earth's ionosphere, atmosphere and climate. Astronomy research covers spacecraft exploration of the solar system, the structure and evolution of galaxies, and the events of the highest energy in the universe.

Research carried out in the group has contributed to major scientific advances on the international level, which manifests in a large number of publications (including 7 in Nature and Science in 2013-2018), having received a high number of citations as well as attention from the popular press.

The results also have societal impact, e.g. evaluating the radiation doses on aircraft passengers during solar storms, ground-induced currents during ionospheric storms affecting power transformers, and climate effects of energetic particle precipitation from the near-Earth space. Many aspects of the research meet the interest of the general public in the `big' questions like `where do we come from' and `what is our place in the universe'.

Current description of the RU (rating 6)

The RU has developed a number truly world-leading research outputs and have fundamentally contributed the mergence of a new research field, space climate. In particular, in Space Physics their contribution to unveiling some principal physical laws in long-term (´space climate´), and short-term (´space weather´) variations in solar activity and their effects on the near-Earth space, the Earth's ionosphere, atmosphere and climate is exemplary. The research has significant impact on the current state of art in these disciplines.

In the Astronomy sub-division of the RU the focus is on the evolution of galaxies in the universe, the high-energy physics of binary star systems, as well as the dynamics of dust (micrometeoroids) in the solar system and the formation and evolution of planetary ring systems. There, contribution is also made at very high standards (see, e.g. participation in the Euclid OU-EXT work package).

The RU has made a number of fundamental contributions that has enabled them to lead national and international collaborations. The international visibility of the RU is significant, especially the solar and space physics (i.e. space climate).

The methodological approaches are very solid, as evidenced by the RU's involvement in EISCAT, ESA SSA, ESA's Lagrange mission, Euclid). The research funding is excellent, the RU has generated through their leading or contributing involvements considerable national and international funding (ReSoLVE, eHeroes, EISCAT, ITNs, missions, …).

Future potential of the RU (rating 5)

The RU intends to build upon previous successful research and also plans to benefit from the University's strategic focus area "Changing climate and Northern environment". This latter is a particularly important direction, given the strategic R&D of horizon 2020. The RU has integrated the Institution's strategy into their mid- and long-term research planning.

Based on past performance and the evidence provided, it is mot likely that the RU will remain at the frontiers of internationally cutting-edge research and research training. For this, they may need to spread out a bit their portfolio in terms of age-profile, and secure assurance from the Institution to recruit suitable succession. This should be done "now" and not when perhaps retirement is far too close. Often, institutions make the mistake to build up succession of their best academic assets at a far too late stage. The RU has provided evidence that they do have the vision, so it is recommended that this vision is supported and exploited by the Institution.

The RU has recognized that some of their research has exceptionally important societal impact. A prominent example of this is the research of coupling between solar activity, the magnetosphere and ionosphere, and the lower atmosphere in order to elucidate the importance of these for our climate and weather including cyclic changes. They build on this, and have provided sufficient credible evidence that there is vision of how to expand and strengthen further this impact, even with policy makers at highest international standards (e.g. ICCP). This is not an easy task, especially for such a relatively mall size of RU.

The UN sustainable development goals are considered clearly when applicable, given that space climate is one of the focus areas, that is also research strength of this RU.

On the other hand, although the continued research into for example extragalactic astronomy hardly can be considered a part of UN sustainable goals, it is research at the very forefront, and will utilize the current and coming observational facilities to advance our understanding.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

RU has developed a number truly world-leading research outputs and have fundamentally contributed the mergence of a new research field, space climate.

Contribution to unveiling some principal physical laws in long-term (ʹspace climateʹ), and short-term (ʹspace weatherʹ) variations in solar activity and their effects on the near-Earth space, the Earth's ionosphere, atmosphere and climate is exemplary.

Euclid OU-EXT work package.

Exceptionally strong asset of the RU in regards of appropriate research infrastructures to support high-quality research: e.g., EISCAT, Oulu Cosmic Ray station, Surface Dust Analyser instrument and the JANUS camera, and the access to ESO facilities.

Strengths and development areas:

Strong publication strategy, evidenced by the large number of publications.

7 Nature and Science papers in the period of 2013-2018).

Received a high number of citations.

Leading contribution to EISCAT.

Oulu Cosmic Ray station is an important data provider for the relevant field.

International climate and paleoclimate model intercomparison projects (i.e. in CMIP6/PMIP4) that also directly influence IPCC reporting.
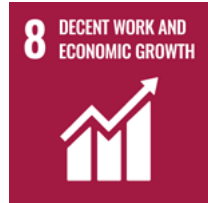
Recommendations:

Institutional support to the RU with academic posts, especially at junior levels, in order to remain at the frontiers of the field.

Institutional support to increase the nr of PhD students and even PDRA posts.

Support the RU to participate in EU (e.g. Horizon Europe) and international projects with in-kind or cash underwriting, as this RU will make break-even the books at least.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

| 4 QUALITY EDUCATION | 8 DECENT WORK AND ECONOMIC GROWTH | 11 SUSTAINABLE CITIES AND COMMUNITIES | 13 CLIMATE ACTION | 17 PARTNERSHIPS FOR THE GOALS |

Sustainable Chemistry (SusChem), Faculty of Technology
RAE2020 code: NSE 28

RU Leader:
Lassi, Ulla

Professors:
Lassi, Ulla – Perämäki, Paavo
– Pursiainen, Jouni

Other PIs:
Heiskanen, Juha – Hu, Tao

Academic Staff in 2019	32
Professors	3
Senior Researchers	3
Postdoctoral Researchers	9
Doctoral Students	12
Researchers on Personal Grant	2
In Teaching only	4
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	4

General description of the RU

Research unit of Sustainable Chemistry (SusChem) is an active and versatile research unit in the Faculty of Technology. Unit works in the research field of sustainable material chemistry, taking also the main responsibility of the B.Sc. and M.Sc. education in the degree programs of Chemistry. Currently, unit has over 40 employees. During the short history of the unit (2015-), main research areas have been in catalytic materials, materials for energy storage, sustainable bioeconomy, water treatment and trace element analysis. SusChem unit was created with a mission to study chemistry challenges in a sustainable way, and to respond efficiently to pressing societal challenges by providing sustainable solutions. This is done in close collaboration with the national and international companies and other relevant actors (universities, research institutes). Innovations from the chemical and metal refining industry sector are seen essential to achieve the transition towards a sustainable low-carbon economy and circular economy, which is supporting the strategy of UOulu.

Current description of the RU (rating 4)

The research conducted at the RU is directed towards chemical conversion and modification of biomass into new chemicals and materials for a broad range of applications. The applied value of the research carried out in the RU is significant and mainly oriented towards water purification and energy storage materials. These are very competitive fields of research and the RU has a short history. The scientific excellence of the RU can be strengthen in the coming years.

The RU is collaborating internationally with several research groups. Relevant partners have been identified for these collaborations. The broad range of collaborators and their specific expertise is consistent and well aligned with the broad range of potential applications of the research conducted at the RU. Exchanges of personnel usually take place, which sometimes result in joint PhD thesis and generate co-authored publications. Joint projects and co-authored publications are also carried out in the framework of national collaborations with the main Finnish research infrastructures, and also internally within the University of Oulu. According to the bibliometric analysis of the Oulu University Library, very few single RU articles are published and the majority involves national and internal collaborations, which are highly effective. The RU is therefore visible both internationally and nationally.

It is difficult to assess the relevance and originality of the research conducted in the RU, which is described in a very generic way. The innovativeness of the research conducted at the RU is not properly highlighted and should be more detailed.

The staff of the RU is actively engaged in different professional communities. The research conducted at the RU can be easily integrated into major societal issues and challenges. The bioeconomy sector and increased use of biomass have the potential to develop new business opportunities. The RU has the possibility to respond efficiently to some pressing societal challenges by providing sustainable solutions. There is a close connection between the scientific research conducted at the RU and the chemistry program at the University of Oulu. The collaboration with industrial partners is also an important asset of the RU, demonstrated through numerous industrial projects, a good patenting activity and PhD co-supervision by industrial partners. The RU is active in civil society and in the social media.

The total research funding is globally low when compared to other RUs. It is mainly based on national funding from Business Finland and Academy of Finland. The RU is very well equipped and the research infrastructure strongly supports high quality research.

The members of the RU are well established in the local and national landscape, but their international recognition is limited. Their career path is significantly lacking in geographical mobility. The life of the laboratory seems to be well organized and the members of the RU are well involved in the Faculty. The activities of the RU are well connected with the focus "Sustainable materials and systems" coordinated by the Kvantum institute, which is one of the four focus institutes at the University of Oulu. It is supportive of high quality research.

Future potential of the RU (rating 4)

The RU recognizes that it can provide sustainable solutions to address some pressing societal challenges and assist the transition towards a sustainable low-carbon economy and circular economy. The scientific objectives for the future are in the continuation of the works already engaged. Their innovativeness is difficult to assess because the ongoing research is poorly detailed in the description. However, the prospects are well described and identified for each group of the RU. It mainly focuses on the development of new materials from biomass, e.g. foam catalysts, adsorbents, energy storage materials, etc, but also analytical methods. The RU intends to make a stronger commitment in internal, national and international networks, and promote more effectively the mobility of doctoral students, advisors and researchers.

The future research goals appear realistic since they are based on ongoing actions. Financial resources must be consolidated and recruitment must be more open at the international, or at least national level.

Highlights, strengths and development areas, recommendations and overall rating (4)

Highlights:

The RU is active in civil society and in the social media.

The staff of the RU is actively engaged in different professional communities.

Strengths and development areas:

The RU is engaged in a topical research area, perfectly in line with research focus areas of the University of Oulu.

The RU is well equipped.

The members of the RU are well established in the local and national landscape, but their international recognition is limited and their career path is significantly lacking in geographical mobility.

The RU is actively engaged in collaborations with relevant partners and closely working with companies.

There is a close connection between the scientific research conducted at the RU and the chemistry program at the University of Oulu.

Recommendations:

The recruitment of researchers on an international/national basis with different scientific backgrounds should be strengthened.

The mobility of young researchers should be promoted.

The research funding needs to be improved.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

Center for Ubiquitous Computing (UBICOMP), Faculty of Information Technology and Electrical Engineering

RAE2020 code: NSE 29

RU Leader:
Ojala, Timo

Professors:
LaValle, Steven – Ojala, Timo – Riekki, Jukka

Other PIs:
Georgiev, Georgi – Pirttikangas, Susanna – Teixeira Ferreira, Denzil

Academic Staff in 2019	39
Professors	3
Senior Researchers	4
Postdoctoral Researchers	12
Doctoral Students	19
Researchers on Personal Grant	0
In Teaching only	1
Of these:	
Principal Investigators	5
Docents (Adjunct Professors)	8

General description of the RU

UBICOMP comprises of five independent research groups. Crowd Computing (CC) investigates the next frontier of collective computing, where humans and algorithms collaborate to solve problems that are too challenging for computers alone. Community Instrumentation and Awareness (CIA) leverages ubiquitous instrumentation to understand individual and social human behavior in naturalistic settings. Design Research (DR) focuses on understanding, supporting and empowering fundamental human capabilities and behavioral traits in the creative design of interactive artifacts and environments. Interactive Edge (iEDGE) applies distributed artificial intelligence for adaptive, reliable and trusted edge computing, to optimize local computing power for applications supporting humans. Perception Engineering (PE) group studies the scientific and engineering foundations of creating and experiencing perceptual illusions, to guide the design of future virtual reality (VR) systems.

Current description of the RU (rating 6)

The RU is active in the area of AI and human interaction in many diverse fields of applications. The RU research is very heterogeneous and exerts strong impact on the field. The research in each of the research groups is theoretically, methodologically and experimentally very solid and contributes to the state of the art. The research originating from several groups within RU has led to important discoveries in the scientific world.

The RU's publication output is of excellent quality and reflects the productivity of the RU groups. One can observe from the listed publications that the RU serves a large variety of top-level journals. The RU personnel have a top-level position and impact in the scientific field. The researchers of the RU have been taking active role in international and national research activities through board appointments and participation in large-scale national and international projects, organizing conferences, and participating in societal decision-making bodies. The RU had and continues to have a large number of international and industrial projects and holds close collaboration with European scientists, as can be seen from the large number of EU projects.

Future potential of the RU (rating 6)

The RU has a clear and very ambitious scientific goals for the next years, which will result in an excellent position within the scientific community. Many of the fields approached in the development strategy are still in development within the scientific communities and will flourish in the next many years. The objectives are very clearly described and measured against societal challenges. The RU has identified as an important goal to increase the intra-RU cooperation and research in order to create a more stringent research body.

The goals set by the RU are realistic and can be fully reached. The risks are well analyzed and mitigation steps have been identified. The RU starts from an excellent international research position and has identified goals, which will sustain or even improve this position.

Highlights, strengths and development areas, recommendations and overall rating (6)

Highlights:

Very strong interaction between engineering and reverse engineering creates an environment for holistic AI-based approaches to real world problems: see the projects 'Reboot Finland as IoT factory' or I'LLUSIVE – Foundations of Perception Engineering (ERC Advanced Grant)'.

Strengths and development areas:

Promote productive stability after several years of constant change. Identify further research collaboration opportunities between the five research groups. Establish dedicated research infrastructure and personnel for conducting human subject experiments in rigorous and high-quality manner.

Recommendations:

Very successful RU which is encouraged to continue as outlined.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

1 NO POVERTY	2 ZERO HUNGER	3 GOOD HEALTH AND WELL-BEING	4 QUALITY EDUCATION	5 GENDER EQUALITY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	10 REDUCED INEQUALITIES	11 SUSTAINABLE CITIES AND COMMUNITIES	13 CLIMATE ACTION	15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS				

Water, Energy and Environmental Engineering (WE3), Faculty of Technology

RAE2020 code: NSE 30

Primary panel: Natural Sciences and Engineering
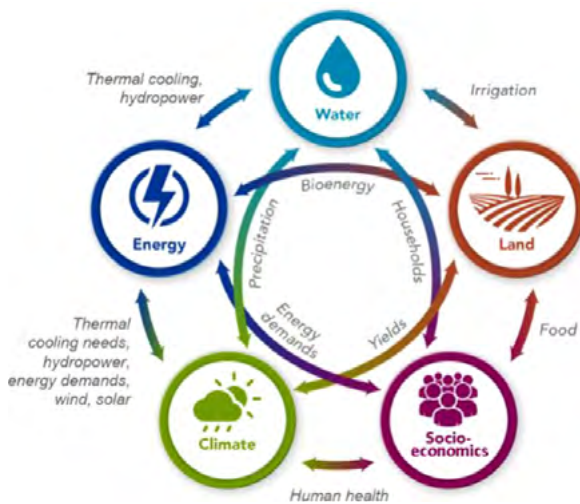**Secondary panel: Biosciences, Health and the Environment**

RU Leader:
Klöve, Björn

Professors:
Klöve, Björn – Pongracz, Eva

Other PIs:
Ronkanen, Anna-Kaisa – Marttila, Hannu – Ala-Aho, Pertti – Calo, Antonio – Heiderscheidt, Elisangela – Kujala, Katharina – Louis, Jean-Nicolas – Piippo, Sari – Rossi, Pekka – Torabi Haghighi, Ali – Ylä-Mella, Jenni

Academic Staff in 2019	47
Professors	2
Senior Researchers	2
Postdoctoral Researchers	13
Doctoral Students	23
Researchers on Personal Grant	7
In Teaching only	0
Of these:	
Principal Investigators	13
Docents (Adjunct Professors)	5

General description of the RU

Water, Energy and Environmental Engineering Research Unit (WE3) conducts research on the sustainable management of land, water and energy resources. The unit carries out research in disciplines such as hydrology, water and energy resources, energy systems, water supply and wastewater treatment, ecological and environmental engineering. The unit mission is to work towards a better understanding of the Water-Land-Energy-Climate Nexus as the way we produce energy and manage water resources impacts on land resources and both are affected by climate change. The unit aims is to find solutions to regionally and globally important issues regarding sustainable use of critical resources which societies and ecosystems demand in the way that environmental impacts are minimized. While the research and our educational programmes are based in science and engineering, we seek to find sustainable solutions with a broad collaboration across various academic fields (e.g. economy, social sciences, urban planning, law, ecology, microbiology, geography and geology), encompassing also new areas of collaboration including e.g. IT/IoT solutions, health, architecture, food production thus providing an integrated and sustainable approach to important environmental challenges. The unit has strong links to research groups internationally as well as to various stakeholders in Finland that participate in our projects, including ministries, cities and municipalities. We are organized into 4 research groups: Northern Hydrology, Water Protection and Ecological Engineering, Hydrosystems engineering and management, Energy and Environment.

Current description of the RU (rating 5)

The research in the Water, Energy and Environmental Engineering RU aims to better understand and characterize land, water and energy resources in order to address issues on use of critical resources via sustainable approaches. The description of the activities is very short but they have shown a strong

expertise in hydrology and water research related to hydrological processes, modelling and management. The energy part focuses on research in smart and sustainable energy systems and circular economy.

The RU is internationally recognized and has strong collaboration in Finland and with Nordic countries (Artic research) or European countries. They also have collaborations with countries where water is scarce inducing strong issues in some case similar to Finland. The RU has significant involvement in European programs and also interactions with Finnish governmental bodies and institutions. The success of these collaborations is underlined with the high percentage of collaborative publications (65%) or with international collaborators (37%). The staff of the RU is international, 25% of the PhD students are Finnish, and a significant proportion of international researchers are leading the RU. This indicates an active strategy of recruiting widely both nationally and internationally.

The topics of research of the RU has a significant societal impact (for example to measure pollution, to limit wastewater, to restore ecosystems). The research concerns also impacts of climate change in the Artic or on energy need, which are important topics.

The research funding level is good with a high level of competitive funding. The RU is strongly involved in many European projects (H2020, Eranet), but also in competitive Finnish projects (Academy of Finland for example), and each senior staff of the RU is involved in writing projects. The objective to develop national or international connections to get financial support is underlined. The RU is in charge of some infrastructure but part of this is old. Either new equipment must be obtained, or the topics should be studied in collaboration with other teams that possess the proper modern equipment.

The research topics of the RU is in line with the faculty objective and the RU has strong interactions with several other RUs within the University.

The RU was formed in 2018 by merging RU from research on water and engineering with RU from research on energy. This latter one represents ca ¼ of the RU. The fusion is not yet fully implemented.

Future potential of the RU (rating 5)

It is explicitly mentioned that merging of several smaller RU's was requested to drive to the formation of the actual RU. This merging is recent (2018) and is still somewhat under way (there are still 2 distinct websites).

Efforts to describe more integrated research are visible in the future research strategy, with a common objective to develop research to address issues to develop and manage critical resources (land, water and energy).

The 4 teams in the RU propose somewhat independent future objectives, that are relatively briefly described. Modelling approaches are at the heart of the future research. Synergy is expected with the complete integration of both parts (water and energy) of the RU.

The research axes are in line with significant societal challenges concerning cities and also Artic and Boreal systems, but also water-food-energy research, remote sensing in modelling, and water management.

Highlights, strengths and development areas, recommendations and overall rating (5)

Highlights:

- The RU is well recognized in the field of research

- The international visibility is clear with involvement in many European projects

- The level of publication of the RU is good.

Strengths and development areas:

- The societal aspects of the research is significant;

- The RU is very dynamic with involvement of many people to apply to different projects.

- The global funding is good.

Recommendations:

The RU is new (in its present composition) and it is essential to continue to integrate both parts (water and energy) to get synergy of these two components.

The research of this RU supports the following United Nations Sustainable Development Goals (SDG):

2 ZERO HUNGER

6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

4.3.2. Summary report of the NSE Panel

Overall assessment

The panel Natural Science and Engineering (NSE) is the largest panel comprising altogether 30 research units (RUs) with research areas ranging from pure mathematics to civil engineering and architecture. The size of the RUs varies from rather small ones with less than 5 leading scientists (Principal Investigators) to large multidisciplinary groups with more than 10 leading scientists. All RUs engage actively in research in addition to their teaching and administration duties. The scientific output is predominantly disseminated in international journals, international conferences, and in patents. Other ways of scientific communications are know-how transfer to industry in terms of joint projects or contributions to internal databases.

External funding of the research is obtained from Finnish organizations such as the Academy of Finland and Tekes, and from international bodies, predominantly European Union. In general, the success rate of the RUs in competitive programs is very good with a substantial number of both Academy of Finland projects and approved Horizon 2020 proposals. Many RUs in the NSE panel double their funding by external sources compared to the internal financial support given by Oulu University.

The RUs in the NSE panel are actively participating in the focus areas of Oulu University, with very strong contributions to the focus areas "Sustainable materials and systems" and "Digitalization and smart society" and also with significant work to the field of "Changing climate and northern environment". All RUs are committed to reaching the sustainability and development goals (SDGs) laid down by the UN. The world-leading 6G flagship of Oulu University is led by members of the NSE panel.

Overall, the scientific level of the research conducted by the panel RUs has high impact and reaches top standards, which is reflected by the fact that 4 RUs were graded with straight 6/6 by the evaluation panel, and that the average grade approaches 5/6.

Plans for strategic development were outlined, and were judged to have been developed on the basis of a sound assessment of the current state in almost all cases. Strategic development "at work" can be observed by the continuous realignment of the research areas with the focus areas, in particular in the area of sustainability, which is about to open new and exciting research fields.

Strengths and development areas

Strengths

In general, there is an excellent match between the research areas of the RUs in NSE and the focus areas of Oulu University, in particular in the case of "Sustainable materials and systems", "Digitalization and smart society" and "Changing climate and northern environment". Oulu University is developing a unique profile in these areas which sets them apart from other research units both on a national and an international level.

Research in a university environment is predominantly person-based, and is often confronted with the problem of continuity after retirement of top researchers. The RUs of Oulu University in the field of NSE have dealt with this problem in the past and found very promising new leaders both from Finland and from abroad. In the course of this ongoing renewal process, the number of female researches in top positions has increased significantly.

The RUs have developed guidelines how to improve the quality of their research environment, and seem to be quite successful in putting them into practice. Young researchers are encouraged to work on an international basis and develop their own profile. Research equipment seems to be on a high level and well-maintained including continuous updating.

Development areas

Some RUs are too small to be competitive, and others consist of research groups with no common denominator.

RUs with strong ties in industry are pushed towards more "scientific" work. However, their work is valuable in the development of local and national industry, and they should be evaluated with focus on the efficiency of know-how-transfer.

Mathematics is a basic subject in almost all curricula in NSE. The corresponding RUs struggle with the high teaching load, and their research potential is not fully exploited in some cases. On the research side, there is a benefit from integrating maths in applications, and additional efforts may be needed in this field.

The teaching load is unevenly distributed among the RUs, some being loaded with substantial teaching duties. Some RUs rely on foreign scientists to cope with the research activities, which on the other hand limits the teaching involvement, especially on the under-graduate level. Additional support is needed, as this problem may become prevalent in high-profile areas where Oulu University can attract top researchers from around the world.

Good practices and recommendations

Good practices

Oulu University provides a research environment fostering new ideas and research fields. The focus areas reflect well the strengths of the research units in natural sciences and engineering and will significantly contribute to define a specific and attractive profile of the university.

The defined framework of research units promotes interdisciplinary research with high level outcomes. Researchers at Oulu strive for scientific excellence, but are also aware of the societal impact of their work and their responsibility for the well-being of society both on a national and international level.

Research in natural science and engineering is internationally visible, but deals also with local challenges ranging from supporting local industry to protecting arctic environment.

Recommendations

The strong focus on bibliometric data as a route for success is too narrow for the wide field of natural science and engineering, as methods for dissemination of scientific outcomes vary strongly from discipline to discipline. Highly specialized areas (e.g. as pure mathematics) cannot compete with team-oriented scientific fields in life-science or physics in terms of citations or number of publications, but may also be on very high international standing.

Even though the overall goals and are essential for developing a consistent profile of the university, there should be always space for side-streams which may foster the next generation goals. More specifically, fundamental research should be recognized in its own right, maybe even in terms of an additional focus area.

The SDGs of the UN will and should be the yard-stick for decision makers in the future. However, relation between SDGs and academic research is not always obvious, and it is hard to provide evidence for substantial activities of the research groups in this field.

Oulu University has achieved a very prominent international standing in some fields, and is therefore attractive for international researchers. Opening the undergraduate programs for courses in English will help to distribute the teaching load more evenly and may help to attract gifted international students form their first day in university.

5. Summary and conclusions – Panels' university level findings and recommendations

5.1. Overall assessment

The University Management should be aware of differences in research cultures among disciplines, and how these impact on the statements we make below. Across the university, there is an enormous range of research disciplines and research is not always measurable within one-size fits-all approaches.

- Research Units (RUs) are the base of research organization of the University of Oulu.

- The RUs of the University of Oulu engage actively in research and achieve extremely high standards, with several being world leading.

- The size of the RUs varies considerably, ranging from powerful multidisciplinary research groups to rather small groups centred around one top researcher.

- Managing RUs is a dynamic process which has to be monitored continuously. Key issues are: continuity following retirement of key researchers; subcritical sizes; and non-interacting groups within RUs. Proactive management is required to address each of these issues to ensure the continuity of research.

- The University of Oulu has defined five focus areas giving the university a unique profile. These focus areas are directly related to the sustainability and development goals (SDGs) of the UN.

- The RUs are aligned very well with these focus areas and use them for developing ambitious, yet feasible strategic plans.

- The cross-sectional focus area "Changing climate and Northern environment" benefits from contributions of the RUs of all panels, whereas the others are more panel specific.

- Societal impact is an important aspect of which all RUs are aware with special efforts directed towards regional benefits.

5.2. Strengths and development areas

Strengths

- There is a large group of RUs which are very successful in supporting projects through competitive funding, both on national and international levels.

- Many RU members are prominent in their fields and are highly influential.

- Many collaborations exist on national and an international levels.

- The focus areas provide clear guidelines for developing a unique profile for the University of Oulu. These research foci are important in shaping the research strategies of the RUs.

- There are typically supportive and friendly environments and infrastructures/facilities designed to encourage growth of all members of each RU. The intellectual climate in the RUs appears to be conducive to research.

- The RUs ambitiously pursue their present strategy and are committed to refining it in the future, always with a view to strong involvement in international research and to making a strong contribution to the northern Finnish community.

- All RUs recognize the need for internationally high quality publications, and are committed to achieve this goal.

- Research in a university environment is predominantly investigator driven. Research Units are often confronted with the problem of continuity after the retirement of top researchers. The RUs of Oulu University have dealt with this problem in the past and found very promising new leaders both from Finland and from abroad.

- In the course of this ongoing renewal process, the number of female researches in top positions has increased significantly.

Development areas

- Some RUs are too small to be competitive or viable, and others consist of research groups with no common denominator.

- RUs with strong ties to the end user are pushed towards more "scientific" work. However, their work is valuable in regional and national development. They contribute significantly to improve societal impact, and they should be evaluated on an alternative scale.

- The teaching load is unevenly distributed among the RUs, with some investigators being loaded with substantial teaching duties.

- Some RUs have attracted foreign scientists to strengthen research which, owing to language barriers, limits their teaching involvement, especially at the under-graduate level. This may become prevalent in high-profile areas where Oulu University can attract top researchers from around the world, but risks creating a division between research and teaching.

- Succession planning is critical. Some small RUs are dependent on a small number of senior researchers. Without a plan for recruitment of junior staff, there is a danger that these RUs will not be sustained.

- There are fields in which applications for competitive funding should be further encouraged whenever applicable, subject to field specifics.

5.3. Good practices and recommendations

Good practices

- Oulu University provides a research environment fostering new ideas and research fields.

- There is a focus on high quality outputs, ensuring that RUs are ambitious to be at the forefront of their fields.

- The defined framework of research units promotes interdisciplinary research with high level outcomes.

- There are well-established links with society and local culture, and research impact is a strength of Oulu.

- There are many well organised RUs with well-developed, inclusive management structures. These foster career development, training of scientists as well as strategic thinking about the future of research.

Recommendations

- The strong focus on bibliometric data as a route for success is too narrow for the wide breadth of research covered by the RUs: methods for dissemination of scientific outcomes vary strongly from discipline to discipline. In the more applied areas, there is much excellent end-user engagement and research impact, but this is not readily captured by current research metrics.

- Oulu University has achieved prominent international standing in some fields and is therefore attractive for international researchers. Opening the undergraduate programs for courses in English will help to distribute the teaching load more evenly and may contribute to attracting gifted international students from their first day in university.

- Though the research at the University of Oulu is thematically creative and original, the university should ensure that investment in the five focus areas does not hamper future development. There should be always space and resources for new streams which may foster the next generation of goals. One danger is that fundamental basic research is not valued in its own right, even though it could potentially be recognised as an additional focus area.

Appendices

SELF-EVALUATION AND SCIENTIFIC ACTION PLAN TEMPLATE FOR RESEARCH UNITS - GENERAL INSTRUCTIONS

> This document contains instructions for completing the Research Unit specific RAE2020 self-evaluation + scientific action plan form. Please submit the form and appendices as one aggregated document (Name of research unit.PDF) to the Registry Office of the University of Oulu (kirjaamo@oulu.fi) by 15.05.2020.

RAE2020 (Research Assessment Exercise 2020) at the University of Oulu supports Research Units (RUs) in identifying their research strengths, weaknesses and development potential and in defining the most urgent and relevant measures needed for improvements in the working environment and to reach their full potential in scientific research. The RAE also provides the University with an overview of its research activities and the results will be used to develop these activities further.

The starting point for RAE2020 is the preparation of a critical Self-Evaluation and a Scientific Action Plan (hereafter jointly Self-Evaluation Report) by each RU. RUs are encouraged to engage academic staff from all research career stages in the process to ensure multi-voiced views on research development. Please note that preparing the Self-Evaluation Report is a demanding process – sufficient time must therefore be set aside for it by the RU.

Three international evaluation panels are invited to evaluate and give feedback to the RUs on their Self-Evaluation Report. Please note that the external expert panels will use the Self-Evaluation Report, bibliometric analyses and the face-to-face meeting with the RU as information sources when evaluating the state of the research and research environment and the proposed development actions. When writing your Self-Evaluation Report, keep in mind that the expertise areas of the multi-disciplinary panel members may not correspond precisely to the disciplines of the University.

When considering the topics of the Self-Evaluation Report, please do not only focus on the outcomes of the RU but also describe relevant actions, e.g. researcher recruitment. The evaluation period of the Self-Evaluation Report is from 2013 onwards.

Support your conclusions by referring to the results from the bibliometric analyses, other aggregated statistical data for the RU, and any other information source that you find relevant. Please focus on the level of the RU. The maximum length of text per topic is specified as either 0.5, 1.0 or 3 pages. This document contains instructions for filling in the RU-specific form. The latter RU-specific form contains pre-filled parts and fields to be filled in by the RU. The required font is Calibri body, font size 12 pt and line spacing 1.15. All bibliographic references in the Scientific Action Plan part must be added directly to the text in the format: Author(s) Year (not as footnotes). The maximum length of the whole Self-Evaluation Report is 15 pages.

CONTENT of the Self-Evaluation Report: General public description of the RU: 1. Basic information, 2. Reflective analyses, 3. Scientific Action Plan and 4. Organization of work involved in completing the Self-Evaluation and Scientific Action Plan.

FOLLOW-UP of the RAE2020 Self-Evaluation: Follow-up of realization of the feedback from the evaluation panels and the research development plans will be conducted 1–2 years after the RAE2020.

SELF-EVALUATION AND SCIENTIFIC ACTION PLAN TEMPLATE FOR RESEARCH UNITS

Name of RU: [Pre-filled]

Director of RU: [Pre-filled]

University focus area: [Pre-filled]

Profiling area (if applicable): [Pre-filled]

Web page(s) representing the RU: [Write here]

GENERAL PUBLIC DESCRIPTION OF THE UNIT

Describe the topics and the significance of the research from the perspective of science and society and the site(s) of the research (max. 1000 characters excluding spaces).

[Write here]

1. BASIC INFORMATION

1.1. Profile and organization (max. 1 page)

Describe in brief the RU's current profile and organization:

A. Outline the scientific profile.

[Write here]

B. Provide a concise description of the RU's organization and composition (leadership and management practices, research groups, disciplines, sub disciplines, joint positions with other organizations).

[Write here]

C. Specify possible national and international tasks, roles and responsibilities of the RU that have an effect, e.g., on its priorities for research targets or resource allocation.

[Write here]

D. Provide a short summary of the RU's organizational history, including the main changes since 2013 and in the near future.

[Write here]

1.2. Key figures

Key indicator information on personnel, funding, publications and other academic achievements

A. Pre-filled table: Key indicator information on personnel, funding and publications (provided by the administration)

Academic Staff in 2019	XX
Professors	X
Senior Researchers	X
Post docs	X
Doctoral Students	X
On personal grant	X
In teaching only	X
Of these:	
Principal Investigators	X
Title of Docent	X
Competed Research Funding	
National, €/year	XX
International, €/year	XX
Total Funding, €/year	XX
Scientific Publications	XX

Staff, head count 2019

Funding and publications, 2016 - 2018 mean

Total funding: basic funding from Ministry of Education and Culture, competed research funding and other supplementary funding
Scientific publications: peer-reviewed scientific articles & scientific books

B. Information on other academic achievements (max. 0.5 page)

List the RU's other major academic achievements (e.g. Academy of Finland Flagship and Centres of Excellence, and Academy professors, ERC- and other major EU-funded projects, patents, major awards, open access data, reagents, software, intellectual property and datasets, tasks in national and international academic boards).

[Write here]

1.3. Scientific and societal impact

A. Scientific impact (max. 0.5 pages)
Describe the main scientific achievements of the RU since 2013, e.g. breakthroughs, paradigm shifts, new theories and new methods.

[Write here]

B. Societal impact (max. 0.5 pages)
Describe the societal impact of the RU. Societal impact may constitute various contributions, e.g., as described in the Academy of Finland's STATE OF SCIENTIFIC RESEARCH IN FINLAND 2016 (see pages 5 – 10

and Table 1 on page 10) https://www.aka.fi/globalassets/30tiedepoliittinen-toiminta/tieteentila/aka_tieteen_tila_2016_eng_150317.pdf

[Write here]

2. REFLECTIVE ANALYSES

Section 2 identifies structures and processes that characterize the RU and facilitate high quality research. When applicable, please refer to data aggregated for the RU, bibliometric data, and any other evidence. You may consider the following questions in relation to each factor:

- How is the RU currently working to achieve high-quality research and renewal?
- What strengths and weakness do you see in the RU's current performance and approaches?

In what ways could the RU´s current approach be further improved? Are there any ongoing or planned new initiatives?

Does the RU need further support (administrative support, removal of administrative barriers, etc.)?

Focus primarily on what is within the RU's immediate reach and control, i.e., on what can be done – and improved – by the RU itself. In addition, the RU may suggest changes that have to be decided upon – or made – at other levels within the University (e.g. Faculty or University level), and/or by external bodies (e.g. changes in government regulations and research council procedures).

2.1. Assessment of the RU's current output, collaborations and environment

Describe in 2.1. the strategies for publication, competitive funding, collaborations and infrastructures.

2.1.1. Publications – refer to the RAE2020 bibliometric analyses (max. 1 page)

A. Description of publication strategy. Selection of publishing venues. National and international publishing. Open access publishing. Follow-up of the development of RU's publication patterns. How does the RU encourage and facilitate researchers in applying open science principles and practices such as open publishing and making data, material, metadata and methods widely available for reuse?

[Write here]

B. Analysis of bibliometric data. Comment on the RU's research output based on bibliometric data with regard to productivity, citations, and publication channels. Noticeable changes over time? Potential for improvement?

[Write here]

2.1.2. Competitive funding (max. 0.5 page)

Describe the RU's current strategy for obtaining external research funding and the current overall funding situation. What are the RU's plans to secure a sufficient level of external funding in the future?

 [Write here]

2.1.3. Collaborations (max. 1 page)

A. Collaboration and networks with other universities and research institutes. Which are the RU's and its groups' most important national and international collaboration partners, and how are they maintained?

[Write here]

B. Internal collaborations within the University of Oulu. What collaborations are ongoing between the RU and its research groups and other RUs at the University of Oulu? Describe also internal collaborations within the RU. How will the RU develop these activities further?

[Write here]

C. Non-academic collaboration and public outreach activities (See 1.3.). What are the RU's most important collaboration partners outside academia (e.g. companies, municipalities, hospitals)? How is the RU currently working to establish and maintain such collaboration and networks? How does the RU realize wider dissemination of research results to the rest of society? What are the RU's current approaches to stimulate public outreach activities/knowledge utilization/innovation? How will the RU develop these activities further?

[Write here]

2.1.4. Research infrastructures (max. 0.5 page)

How is the RU currently working to maintain and develop the research infrastructures it needs (e.g., instruments, tools and supplies, support staff)? Does the RU use or contribute to university-level, national or international research infrastructures? How does the RU and its research groups manage research data? Suggestions for improvements?

[Write here]

2.2. The RU's academic culture, structures and processes

In section 2.2., consider how the RU is currently working to nurture a culture that is conducive to high quality research and renewal, e.g., regarding intellectual interaction, collegiality, equal opportunity, creativity, ambition, scientific conduct, research integrity? How do you ensure that all researchers in the RU, including early stage researchers (doctoral students and postdocs), are well familiarized with and follow the principles of responsible conduct of research, ethical principles, and legislation relating to their research? Suggestions for improvement?

2.2.1. Research leadership (max. 0.5 page)

A. Research Unit level. Describe how research leadership and communication is organized in the RU, including the roles of individual research group leaders, etc. Suggestions for strengthening research leadership?

[Write here]

B. Faculty/Focus Institute/University level. How do you perceive that the leadership at the Faculty/Focus Institute/University level works to support high-quality research and renewal? Strengths and weakness of approaches? Suggestions for improvement?

[Write here]

2.2.2. Recruitment (max. 0.5 page)

How do the current recruitment processes aim to ensure high-quality research, renewal and maintaining a critical mass at all stages of the research career in the RU (e.g., attracting top-level researchers and teachers, opening new fields of research and balanced recruitment also from outside the University of Oulu)? Are internal career opportunities aimed at attracting and retaining talented researchers being offered? How are equal opportunities of potential applicants ensured? Suggestions for improvement?

[Write here]

2.2.3. Career and mobility (max. 0.5 page)

How is the RU currently working to support researchers to sustain their active career paths, to promote career development and to stimulate mobility (researchers in all career stages)? What support does the RU offer for international collaboration that might boost career development? How are equal opportunities ensured for all researchers of the RU? Suggestions for improvement?

[Write here]

2.2.4. Doctoral education (max. 0.5 page)

A. How are doctoral students recruited and selected in the RU? Describe the practices of agreeing on research topics and questions for doctoral thesis work.

[Write here]

B. What is the role of doctoral students in the research of the RU? How do you integrate the doctoral students into the community and research activities? How do doctoral students receive feedback about their progress?

[Write here]

2.2.5. Research-teaching linkages (max. 0.5 page)

How is the RU currently working to create links between research and teaching in order to improve student learning and research quality? Suggestions for improvement?

[Write here]

2.2.6. Feedback and evaluation in the RU (max. 0.5 page)

How is the RU currently carrying out follow-up and evaluation of the research environment and research outcomes? Are individual researchers given formal or informal feedback on their performance? Suggestions for improvement?

[Write here]

2.3. Other information (max 0.5 page)

Please state below if there are matters of relevance to research quality and renewal that have not been covered above, i.e. themes at the RU level that are important aspects of the preconditions and processes for high-quality research that are central to the RU.

[Write here]

3. SCIENTIFIC ACTION PLAN: Future research strategy and impact of the RU for 2020 – 2025 (max. 3 pages)

Describe the research strategy and evaluate the future research potential of the RU. Based on your answers to the guiding questions, list a maximum of five of the most important development targets in the research activity of the RU. If the RU has taken measures or is planning measures for realizing these targets, please give a short description of them.

Take into consideration the University of Oulu and Faculty strategies, focus areas, and scientific profiling areas in the future goal description. Consider also which of the United Nation's Sustainable Development Goals (https://www.un.org/sustainabledevelopment/sustainable-development-goals/) the RU's research can meet.

Guiding questions:

- What are the future research goals of the RU, including current plans for new research initiatives (major new projects, etc.)?
- Where do you aspire to be in 6 years' time with your research? What are your goals for publishing (and other research outputs) and how will these goals be achieved?
- Which aspects of the RU's research environment are assets that should be further strengthened, and what should be changed?
- What is the expected societal impact of the RU?
- Assess the possible risks associated with implementing the RU's research strategy.

[Write here]

4. ORGANIZATION OF WORK INVOLVED IN COMPLETING THE SELF-EVALUATION (max. 0.5 page)

Describe briefly how the RU has organized the work involved in completing the Self-Evaluation and Scientific Action Plan.

[Write here]

APPENDICES: RESEARCH GROUP LEADERS' AND/OR PRINCIPAL INVESTIGATORS' CVs AND A SELECTED LIST OF UP TO 20 PUBLICATIONS FOR THE ENTIRE RU

The CVs and publication list should be compiled according to the instructions of the Academy of Finland.

The CV should be no more than three pages.

The publication list should represent the RUs activities from 2013 onwards and the maximum number of publications to be included is 20. A similar list was submitted at the pre-registration stage. Please revise the list if needed and submit it as an appendix to the Self-Evaluation Report.

RAE2020
RESEARCH ASSESSMENT EXERCISE 2020

UNIVERSITY OF OULU

Evaluation criteria and rating scale

The expert panel is requested to assess and give a numeric evaluation (rating 1-6) and written feedback of the following parts:

1) The current research performance and research environment based on the Basic information of the Research Units (RUs) (section 1 in the Self-evaluation Report) and Reflective analyses of the RUs (section 2 in the Self-evaluation Report).

Evaluation aspects for numerical and written feedback:

- Scientific quality and impact of research
- Societal impact of research
- Quality of the research environment

2) The future potential, impact and renewal based on the RU's Scientific Action Plan for 2020 – 2025 (section 3 in the Self-evaluation Report).

The rating scale is as follows:

6. Outstanding
5. Excellent
4. Very Good
3. Good
2. Fair
1. Poor

The RU rated as 6 needs to be exceptional in research quality, but the Panels should consider 6 to be a realistic and attainable rating. The rating should be considered in relation to the international level in the fields of the research concerned, not in relation to the other RUs of the University of Oulu.

1. Current research performance and research environment

➢ Basic information and reflective analysis (sections 1 and 2 in the Self-evaluation Report)

Scientific quality and impact of the research

Based on sections 1 and 2, the Appendices (CVs of PIs and a selected list of up to 20 publications for the entire RU), and the Bibliometric analyses of the CWTS and/or the Oulu University Library. When evaluating, consider the quality of publications, not just the quality of the journal (Appendices).

Guiding questions:
- Overall, is the research creative and original? What is the RU's research impact on the scientific development of the field? What are the theoretical and empirical contributions of the research in its field? Is the research methodologically and empirically solid? (1.1.A, 1.3.A)
- Does the RU have a competitive publication strategy? (2.1.1.A) Does the RU encourage researchers to open science principles and practices, e.g. making publications, data, metadata and methods available for reuse?
- Is the RU's publication output of high-quality and productive? (2.1.1.B., Appendices: a selected list of up to 20 publications for the entire RU, and the Bibliometric analyses of CWTS and/or the Oulu University Library).
- What is the position and influence of the members of the RU in the field? (1.2.B and the Appendices: CVs)
- What is the level and the scientific impact of the internal, national and international collaboration of the RU? (2.1.3. and the Bibliometric analysis of the Oulu University Library). Is the research of the RU visible internationally and nationally?

Rating	Rating criteria of the scientific quality and impact of research
6 Outstanding	The research of the RU is of world-leading quality in terms of originality, significance and rigour. It produces new creative ideas and/or approaches and is comparable to the research conducted in the best units in the same field of research. The RU has a notable impact on the scientific development of the field. The RU and its members have leading roles in international research networks and projects.
5 Excellent	The research of the RU is of excellent quality in terms of originality, significance and rigour. The RU has a solid track record of discoveries, findings or openings. Work at this level is published by leading (international) publishers and journals. The RU and its members are valued partners in international research networks and projects.
4 Very good	The research of the RU is of very good quality in terms of originality, significance and rigour. Work at this level is or could be published by well-known (international) publishers and journals. The research of the RU attracts serious attention within the international academic community and is frequently cited. The RU and its members have an established position as experts in the field and as partners in research projects and networks.
3 Good	The research of the RU is of good quality in terms of originality, significance and rigour. Work at this level is published by respected (international) publishers and journals. The research of the RU attracts some attention within the international academic community. The RU and its members have partly established their position as experts in the field and as partners in research projects and networks.
2 Fair	The research of the RU is of fair quality in terms of originality, significance and rigour. Work at this level is published by established publishers and journals. The research of the RU attracts limited attention within the international academic community. The RU and its members are in the process of establishing their position as experts in the field and as partners in research projects and networks.
1 Poor	The research at the RU does not achieve notable results and the RU has a very limited impact in its field.

Societal impact of the research

Based on 1.2.B, 1.3.B. and 2. Reflective analysis - when applicable.

Guiding questions:

- Does the RU consider the societal relevance of its research as an important aspect of its activities?
- Is the research societally relevant and what kind of impacts does it have locally, nationally and/or globally?
- What kind of impacts have the collaborations of the researchers at the RU with non-academic partners, e.g. policymakers, the civil society, business life, the environment and the health care system on the national and/or global scale?

Rating	Rating criteria of the societal impact of research
6 Outstanding	The RU has outstanding societal interactions and impact and its research is of very high relevance in terms of new knowledge and solutions. The RU has identified relevant audiences and stakeholders and set up systematic activities to reach them. The outcomes provide very convincing evidence of societal impact.
5 Excellent	The RU has excellent societal interactions and impact and its research is of high relevance. The RU has wide and dynamic interaction with the society. The RU has identified audiences and stakeholders as well as activities to reach them. The outcomes provide convincing evidence of societal impact.
4 Very good	The RU has very good interactions with the society and its research is relevant for producing new knowledge and solutions for the society. There are activities to reach the society and proof of successful outcomes.
3 Good	The RU has established some interactions with society. For most parts, the research at the RU is relevant to society. The unit has some understanding of the role and positioning of their research in the society.
2 Fair	The RU is developing its interaction with society. The research at the RU has limited societal relevance but has the potential for making a wider impact on society.
1 Poor	The RU has little interaction with the society. For most parts, the RU itself does not perceive the societal relevance of its research.

Quality of the research environment

Based on sections 1. and 2.

Guiding questions:

- What is the level and profile of the research funding? Are there systematic processes/strategies for applying for external funding? (1.2.A . and 2.1.2.)
- Evaluate the national and international research collaborations of the RU: Do members of the RU participate actively in research collaboration with relevant and different types of partners (academic and non-academic)? (2.1.3.A and C)
- How do the collaborations within the RU support the quality of its research? (2.1.3.B)
- When applicable, are there appropriate research infrastructures in order to support high quality research and renewal? Are they used efficiently? Does the RU use or contribute to university-level, national or international research infrastructures? (2.1.4.)
- Do the RU's academic culture (e.g. intellectual interaction, collegiality, equal opportunity, equality, creativity, ambition, scientific conduct, research integrity) and research leadership support high quality in research (e.g. are the leadership and management structure at the RU, and also at Faculty/Focus Institute/University level supportive for high quality research and renewal)? (2.2.)
- Do the recruitment, career and mobility, and structure of the academic staff and its career development support high quality in research? Is there sufficient international mobility among the members of the RU? Is the RU able to attract high-level visitors and staff outside of the University of Oulu? Does recruitment support continuity and renewal of the RU? (2.2.2. & 2.2.3)
- Is there a sustainable balance between research, doctoral supervision and research-teaching linkages? (2.2.4. & 2.2.5.)

Rating	Rating criteria of the quality of the research environment
6 Outstanding	The research environment of the RU is fully comparable to the best international units in the field. Operations and procedures are of outstanding quality, transparent and comprehensively shared in the RU. There are no obstacles in the RU's research environment that prevent it from realizing its full potential for excellence in research.
5 Excellent	Compared to the best international units in the field, the RU provides an excellent research environment. Operations and procedures are of excellent quality, transparent and shared in the RU. There are few obstacles in the RU's research environment that prevent it from realizing its full potential but the RU is usually able to overcome them.
4 Very good	The RU provides a very good research environment in terms of research. Operations and procedures are of very good quality, transparent and shared in the RU. There are some obstacles in the RU's research environment that prevent it from realizing its full potential.
3 Good	The research environment of the RU is on the same level with established academic units in the field across the world. Operations and procedures are of good quality and shared occasionally in the RU.
2 Fair	Operations and procedures are not systematic in the RU. The research environment is still developing towards the level expected from a well-functioning RU in the scientific community.
1 Poor	The research environment of the RU is poor in international comparison. There are several obstacles that prevent the RU from realizing its full potential.

2. Future potential, impact and renewal of the RU

> ➢ Scientific Action Plan: Future research strategy and impact of the RU for 2020-2025

How ambitious is the RUs future research strategy; is the RU's impact likely to increase, remain the same or is it in danger of declining? When assessing the RU´s future research strategy, the panelists should take into account the feasibility of the plan in view of the current state of research. The assessment should focus on section 3, the Scientific Action Plan, but also consider sections 1 and 2.

Evaluate the strategic visions of the RU
- Does the RU have ambitious scientific objectives and goals, and innovative ideas for the future?
- Is the research likely to produce new significant outcomes, scientific breakthroughs and impact?
- How well does the RU realize societal impact in its work?
- Has the RU taken into account the current University of Oulu´s and its Faculties´ strategies, including the research focus areas and strategic profiling areas, when planning actions to improve the quality of research and actions for renewal in the RU in an effective way?
  Has the RU taken into account the UN Sustainable development goals?
  https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Evaluate the feasibility of the Scientific Action Plan
- How realistic are the future research goals of the Scientific Action Plan to reach the aspired level of research (publishing and other research outputs)? Compare current research performance with the future goals.
- Are the development targets of the RU feasible in terms of the operational conditions (renewal of personnel, expertise, financial resources and research infrastructure)? Is the viability of the RU ensured?

Rating	Rating criteria of the future research strategy and impact of the research unit for 2020 – 2025
6 Outstanding	The future research strategy of the RU is of world-leading quality in terms of originality, significance and feasibility. The Scientific Action Plan, when compared to the current research performance, is highly ambitious and innovative, though realistic. The high-gain Scientific Action Plan may include risks. The RU is outstandingly set up for the future in terms of resources, operations and procedures.
5 Excellent	The future research strategy of the RU is of excellent quality in terms of originality, significance and feasibility. The Scientific Action Plan, when compared to current research performance, is ambitious, though realistic. The Scientific Action Plan may include risks. The RU is excellently set up for the future.
4 Very good	The future research strategy of the RU is of very good quality in terms of originality, significance and feasibility. The Scientific Action Plan is in general sound but contains a few elements that could be improved. The RU is very well set up for the future.
3 Good	The future research strategy of the RU is of good quality in terms of originality, significance and feasibility. The Scientific Action Plan is in general sound but contains important elements that should be improved. The RU is adequately set up for the future.
2 Fair	The future research strategy and the Scientific Action Plan of the RU are on developmental phase in terms of originality, significance and feasibility. The RU is not adequately set up for the future.
1 Poor	The quality of the RU's research strategy and Scientific Action Plan is poor in terms of originality, significance and feasibility. The RU is not adequately set up for the future.

Conclusion

CRITERIA	NUMERIC SCALE 1 - 6
1. Current research performance and research environment	[Write here]
1.1. Scientific quality and impact of the research	[Write here]
1.2. Societal impact of the research	[Write here]
1.3. Quality of the research environment	[Write here]
2. Future potential (from a viewpoint of scientific action plan of the RU)	[Write here]
OVERALL ASSESSMENT	[Write here]

The expert panelists may choose to emphasize some sub-elements in the overall assessment. Hence, the rating of the overall assessment does not need to be a mathematical average of the ratings of the sub-elements.

Confidentiality and ethics

The University of Oulu is committed to follow the guidelines of the Finnish Advisory Board on Research Integrity (https://www.tenk.fi/en) for responsible conduct of research. The guidelines also apply to research assessment exercise, and thus reviews are confidential documents. RAE2020 documents should therefore be handled and stored with due care and confidentiality. The panel members are not allowed to disclose any information concerning evaluation documents or reviews or other matters presented to the panels during RAE2020. Confidentiality must also be maintained after RAE2020 evaluation process has been completed.

Conflicts of interest

As a panel member you are required to declare the lack of conflict of interest with subjects of the evaluation. You must disqualify yourself in the following circumstances:

- You have collaborated with University of Oulu researchers (e.g. you have co-authored and published an article or manuscript with the applicant in the past three years 2017 - today, been involved in the preparation of the application, or are involved in the publication or application of the results in the past three years).
- You have been a superior, subordinate or instructor of a University of Oulu researcher in the past three years.
- The University of Oulu researcher is a close person to you. A close person is:
  - your spouse (also de facto), child, grandchild, sibling, parent, grandparent or a person otherwise close to you (e.g. fiancé/e or a close friend), as well as their spouses (also de facto)
  - a sibling of your parent or his/her spouse (also de facto), a child of your sibling, or your previous spouse (also de facto)
  - a child, grandchild, sibling, parent or grandparent of your spouse as well as their spouses (also de facto), or a child of a sibling of your spouse
  - or a half-relative comparable to the above-mentioned persons.

You are also disqualified if your impartiality may be endangered in any other way, or if you feel that you have a conflict of interest and are therefore disqualified to act as a panel member.

If you identify any conflicts of interest, please notify Dr. Aija Ryyppö (aija.ryyppo@oulu.fi) as soon as possible.